GRAND CANYON PERSPECTIVES

A Guide to the Canyon Scenery by Means of Interpretive Panoramas

by

W. Kenneth Hamblin

and

Joseph R. Murphy

Illustrations by William L. Chesser

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Introduction

Nearly a century has passed since Captain C. E. Dutton, one of the earliest interpreters of Grand Canyon scenery, spoke of the Canyon as a "great innovation in modern ideas of scenery", which was "not to be comprehended in a day or a week, nor even in a month", and whose understanding called for a "special culture, requiring time, patience, and long familiarity for its consummation." Within a short span of years the Canyon achieved a popular familiarity unforeseen by Dutton, lost its status as an "innovation", and became one of the best known of all natural phenomena. However, his stipulation regarding the time and patience required to truly comprehend the Canyon is as valid today as it was when first expressed.

So overwhelming is the effect of the Grand Canyon on human imagination that for many people it will ever remain mysterious and incomprehensible. For others, the form and color of the great chasm provide an esthetic fulfillment entirely satisfactory in itself; further interpretation is not required. There are still others, however, who are willing to pursue Dutton's "special culture" in a desire to acquaint themselves with the natural processes which have brought the Canyon to its present spectacular appearance. It is for people of such persuasion that our book has been prepared.

We have written from the premise that while Grand Canyon may indeed be awesome and mysterious, it is anything but incomprehensible. Equipped with an understanding of some of the dynamics of earth processes and biological functions, the observant visitor can piece together much of the story of the Canyon's past, and interpret many aspects of the natural forces operative today.

Readers will readily detect that the "perspectives" in our title is intended to convey multiple meanings; we are obviously concerned with geological and biological perspectives, but have also included some aspects of human history, conservation, geography, and esthetics. That an adequate interpretation of Grand Canyon's natural scenery could emerge from this kind of overall view was the belief that prompted a geologist and an ecologist to cooperate in the attempt.

Our plan has been to select a dozen different panoramic views or perspectives of the Canyon, from Painted Desert on the east to Toroweap Point on the west. The visitor is, in essence, brought to a given point on the Canyon rim and given an interpretive diagram with explanatory text keyed to unique or characteristic features revealed at that particular locale. For purposes of accuracy, the panoramic views were prepared from photographic mosaics. They are thus intended to serve as idealized diagrams, rather than as scenic views as such. The points to receive interpretation were selected on the basis of the significance which each view or area has to offer in the total story of the Canyon as a natural entity. We have found that some of the less visited rim points, such as Pima and Lipan, actually provide more significant interpretive material than some of the more popular areas.

The introductory section (pages 2-15) is intended to supply relevant background material, but no attempt was made to cover all phases of the Canyon story. Excellent books and pamphlets dealing with topics such as the geology, history, wildflowers, animals, and place names of the Grand Canyon are available. If the users of this book find their enjoyment and understanding of the Canyon in any way enhanced, the authors' purposes will have been served.

The writers are grateful for assistance rendered by a number of individuals and organizations. We express particular gratitude to Mr. William L. Chesser, whose artistic efforts provide a focal point for the book. His panoramic treatment of Grand Canyon is without doubt the most significant work of this kind since that of W. H. Holmes. We have received valuable counsel and suggestions from personnel of the National Park Service, particularly Merrill D. Beal, former Chief Park Naturalist, and Warren H. Hill, acting Chief Naturalist at the time of publication. We also appreciate the advice and encouragement given by our colleagues in the departments of Geology and Zoology at Brigham Young University.

modified from Maxson, 1967

THE GEOLOGIC MAP

The geologic map on the facing page is, in one sense, a scale model of the Grand Canyon. It thus provides a means by which the visitor can obtain an accurate concept of the size, shape, and dimensions of the Canyon's many features. In addition to showing the roads, trails, streams, and locations of all major view points, the surface outcrop of all important rock bodies is shown in various tones of brown. Other major structural features such as faults and fold axes are shown with conventional symbols. A few minutes study of this map is an excellent way to become acquainted with the Canyon.

The three major groups of rocks each produce a distinctive pattern on the map. The most obvious is the series of parallel bands representing the horizontal Paleozoic rocks. The youngest formations (Kaibab and Toroweap limestones) follow the rim of the Canyon and extend up the valleys and out around the spurs. The succeeding older formations appear deeper in the Canyon. All patterns of horizontal rocks parallel the contours of the Canyon wall.

The map pattern of the Grand Canyon Series consists of several isolated patches near the river and below the Tapeats Sandstone (the lowest horizontal formation). This is because the rocks of the Grand Canyon series have been tilted and eroded prior to deposition of the younger rocks; they thus occur as isolated wedges. The largest exposure of the Grand Canyon Series is in the eastern part of the Canyon.

The oldest rocks are the Precambrian granites and metamorphic rocks, exposed only in the Granite Gorge in the bottom of the Canyon, in the central and western part of the map area. The outcrop of these rocks follows the Colorado River and its major tributaries, so that the resulting map pattern is dendritic.

The legend at the left of the map indicates the tone and symbols used to express each formation. It is arranged with the oldest formations at the bottom and the youngest at the top.

THE NORTH RIM

The North Rim is open for visitors only during the summer months, as the snow resulting from the higher elevation forces closure of the roads from about mid-October to mid-May. Accommodations and services currently available on the North Rim are described in the Park Service brochure.

Physical Features

The North Rim has been dissected by large tributary valleys which produce great amphitheaters or reentrants extending back from the river more than 10 miles. The trace of the rim is therefore highly irregular, with many long projections extending far out into the Canyon; from these have been produced numerous erosional remnants, which exist as isolated mesas and buttes. Viewpoints from the major spurs which project out into the Canyon, such as Point Sublime and Cape Royal, permit unusually broad panoramas.

Most of the North Rim areas are covered with portions of the famous Kaibab forest, which provides a pleasant foreground and compliments the spectacular Canyon scenery.

THE SOUTH RIM

Visitor Facilities

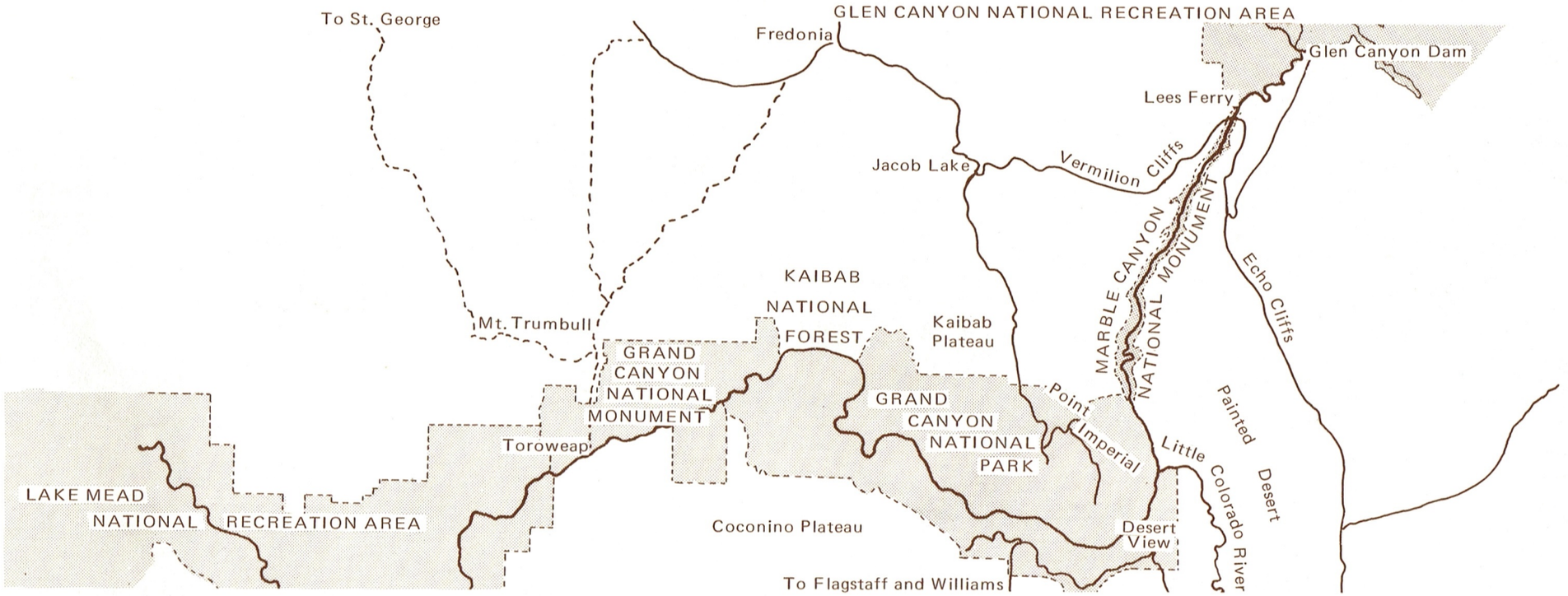
The South Rim is the most visited part of the Park, and is open throughout the year. Excellent visitor facilities are available, offering a wide spectrum of lodging and other services. For up to date information on the available services, see the current Park Service brochure.

Physical Features

The South Rim is relatively undissected, with few isolated buttes and mesas, and most reentrants being only slightly more than a mile back of the projecting spurs. Compared to the North Rim, the south wall is therefore relatively straight. This may be explained by the fact that the regional slope on the South Rim is to the *south,* away from the Canyon rim, so that tributary streams which flow to the river are short and hence supplied with little water. An additional factor contributing to the meager water supply on the South Rim is its relatively low elevation. Most of the area is between 6,000 and 7,000 feet, some 1,000 to 2,000 feet lower than the North Rim. There is therefore generally less precipitation (a mean of 15 inches annually on the South Rim as compared to 27 inches on the North), and much less snow (about 5 feet on the South Rim, and over 10 feet on the North). Owing to these factors, erosion on the South Rim has proceeded at a slower rate than it has on the North Rim. The net effect of this is that the Canyon is asymmetrical, with the North Rim eroded back from the river 3 to 4 times farther than the South Rim.

Views of the Grand Canyon from the South Rim have the advantage of allowing much better perspectives of the river and the inner Canyon than can generally be obtained from the north. Because of the greater dissection of the North Rim, views from the south also afford panoramas of the spectacular temples, buttes, and tributary canyons eroded from the north wall. Some Canyon visitors believe that the South Rim points also offer greater color contrasts, owing to the strong backlighting prevailing there.

Flaming Gorge
Salt Lake City
Ogden
Provo
Vernal
Craig
Laramie
Boulder
Delta
Helper
Grand Junction
Gunnison
Leadville
Salida
Sevier L.
Panguitch
Kanab
Cedar City
Escalante
Needles
Monticello
Durango
Pagosa Springs
Alamosa
Gallup
Flagstaff
Winslow
Holbrook
Petrified Forest
Meteor Crater
Prescott
Kingman
Phoenix
Globe
Williams
Tuba City
Page
Lees Ferry
Mead
Grand Canyon
Zion Canyon
Bryce Canyon
Cedar Breaks
Colorado Plateau
Uinta Mts
Wasatch Plateau
Book Cliffs
Roan Cliffs
Tavaputs Plateau
Grand Mesa
Uncompahgre Plateau
San Juan Mts
La Garita Mts
San Luis Valley
South Park
Park Range
Elkhead Mts
Rabbit Ear Mt
Flattop Mt
White River Plateau
Piceance Basin
Danforth Hills
Laramie Mts
Sierra Madre
Medicine Bow Mts
Mt Lincoln
Mt Elbert
Mt Ellen
Henry Mts
Aquarius Plateau
Kaiparowits Plateau
Table Mt
Circle Cliffs
Waterpocket Fold
Escalante Desert
Great Sage Plain
Gunnison R
Colorado R
San Juan R
Green R
Dirty Devil R
Paria Plateau
Kaibab Plateau
Kaibito Plateau
Echo Cliffs
Vermilion Cliffs
White Cliffs
Pink Cliffs
Gray Cliffs
Grand Wash Cliffs
Hurricane Cliffs
Shivwits Plateau
Uncompahgre Peak
Wheeler Peak
Navajo Mt
Monument Valley
Gothic Mesas
Carrizo Mts
Lukachukai Mts
Chuska Mts
Black Mesa
Hopi Buttes
Defiance Plateau
Moenkopi Plat.
Orabi Mesa
Canyon Mesa
Chacra Mesa
Mesa Prieta
Mesa Verde
La Plata Mts
Ute Pk
Abajo Mts
Sleeping Ute Mt
Needle Mts
Sangre de Cristo Mts
Culebra Peak
Blanca Peak
La Veta Pass
Raton
Trinchera Pk
Taos
Truchas Pk
Sandia Mts
Manzano Mts
Jemez Mts
Nacimiento Mts
Mesa Portales
Mesa Lucero
Mesa Gigante
Mesa Chivato
Mesa Alta
Mesa Gallina
Mesa Verde
Mesa de los Viejos
Mesa Montosa



NATIONAL PARKS, MONUMENTS, AND RECREATION AREAS

The greater part of the Grand Canyon region is now under jurisdiction of Federal agencies charged with the responsibility of maintaining the area in such fashion as will perpetuate its scenic, historic, educational, and esthetic values for the benefit and enjoyment of present and future generations. Nearly the entire length of the Grand Canyon proper, some 280 miles from Lees Ferry to Grand Wash Cliffs, is administered by the National Park Service in Grand Canyon National Park, two National Monuments, and two National Recreation Areas (see map, above). A relatively small segment of the Canyon on the north side of the river from Tapeats Creek to Kanab Canyon is within the boundaries of Kaibab National Forest. Another section west of National Canyon and south of the river is within the Hualapai Indian Reservation. While there are varying philosophies of resource management operative in these different reservations, the areas are generally experiencing wise stewardship. The best hope for the future is that Congress will pass legislation incorporating the entire Grand Canyon and its bordering regions into one unified National Park.

The following brief descriptions treat each of the areas administered by the National Park Service from Lees Ferry downstream:

1. **Glen Canyon National Recreation Area.** This large reservation of 2,232 square miles was authorized in 1958 primarily to administer Lake Powell, which formed behind Glen Canyon Dam. It is of interest here only in that it includes the historic area around Lees Ferry and the actual beginning of the Grand Canyon.

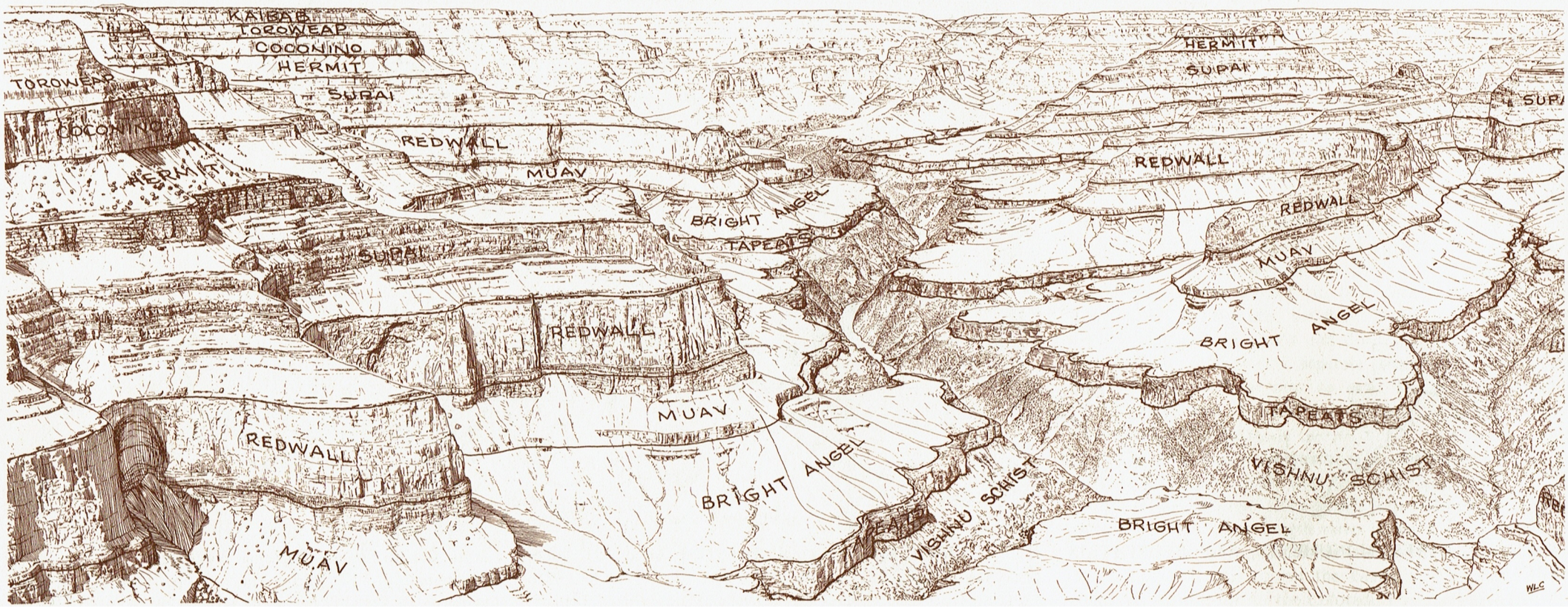
2. **Marble Canyon National Monument.** An area closely paralleling the river and encompassing the first 52 miles of the Marble Canyon section of the Grand Canyon was set aside as a National Monument by executive order of President L. B. Johnson on January 20, 1969. This was the last significant portion of the Canyon to come under protective custody of the National Park Service, an act which hopefully will end the threat of a dam in Marble Canyon and perpetuate the opportunity for visitors to see and experience the entire Canyon by means of float trips.

3. **Grand Canyon National Park.** Efforts to establish a National Park began as early as 1882, but political "infighting" delayed enacting legislation until February 26, 1919. The boundaries of the Park as then established still reflected a considerable degree of political compromise, and the resulting area of slightly over 1,000 square miles was much smaller than Park advocates had hoped for. Fortunately, major areas have been added through Presidential proclamations creating the adjoining National Monuments.

4. **Grand Canyon National Monument.** This consists of approximately 310 square miles lying west of the Park, beginning at Kanab Canyon. It was set aside by Presidential proclamation on December 22, 1932. Major features are the steep, narrow gorge of the Canyon as seen from the broad Esplanade and the spectacular evidences of recent volcanism. The latter include cinder cones, intracanyon lava flows, remnants of lava dams which periodically impounded the waters of the Colorado River, and lava flows which cascaded over the rims into the depths of the Canyon, 3000 feet below. This unique part of the Canyon is presently accessible only by secondary roads from St. George and Kanab, Utah, but it provides an opportunity to visit an area of the Grand Canyon district which is still essentially wilderness.

5. **Lake Mead National Recreation Area.** Roughly 100 miles of the Grand Canyon, lying between the west boundary of the National Monument and the Grand Wash Cliffs, are included within Lake Mead National Recreation Area. Owing to the fact that Lake Mead is an impoundment behind Hoover Dam and is subject to wide fluctuations in water level, the lower reaches of the Canyon have been successively silted in, then re-excavated. As a result, many of the rapids in the Lower Granite Gorge no longer pose a challenge to boaters, as they did during Major Powell's expeditions.

ANATOMY OF THE CRUST



KAIBAB AND TOROWEAP FORMATIONS (PERMIAN)

The Kaibab and Toroweap formations form the uppermost 500 to 700 feet of strata exposed in the Canyon walls, and constitute the surface upon which the Kaibab Plateau on the north and the Coconino Plateau on the south are carved. They are the most widely-exposed formations in the Grand Canyon region. In the eastern part of the Canyon, the Kaibab and Toroweap limestones appear to be separated by a slope which is actually a thin sandy zone in the upper Toroweap Formation. Both formations are characteristically well bedded, as seen in many of the outcrops along the trails. When viewed from a distance, however, stratification is usually obscure. The Kaibab is the uppermost cliff in the Canyon, and many details of the nature of the rock are readily available for the visitor to examine.

The Kaibab and Toroweap limestones are creamy yellow-gray in color, although parts may be stained reddish gray from interbedded colored sandstone and siltstone units. More than 80 genera of invertebrate fossils have been found in the Kaibab and Toroweap formations including large brachiopods, corals, snails, clams, and sponges; a few fossil fish teeth have also been found.

COCONINO SANDSTONE (PERMIAN)

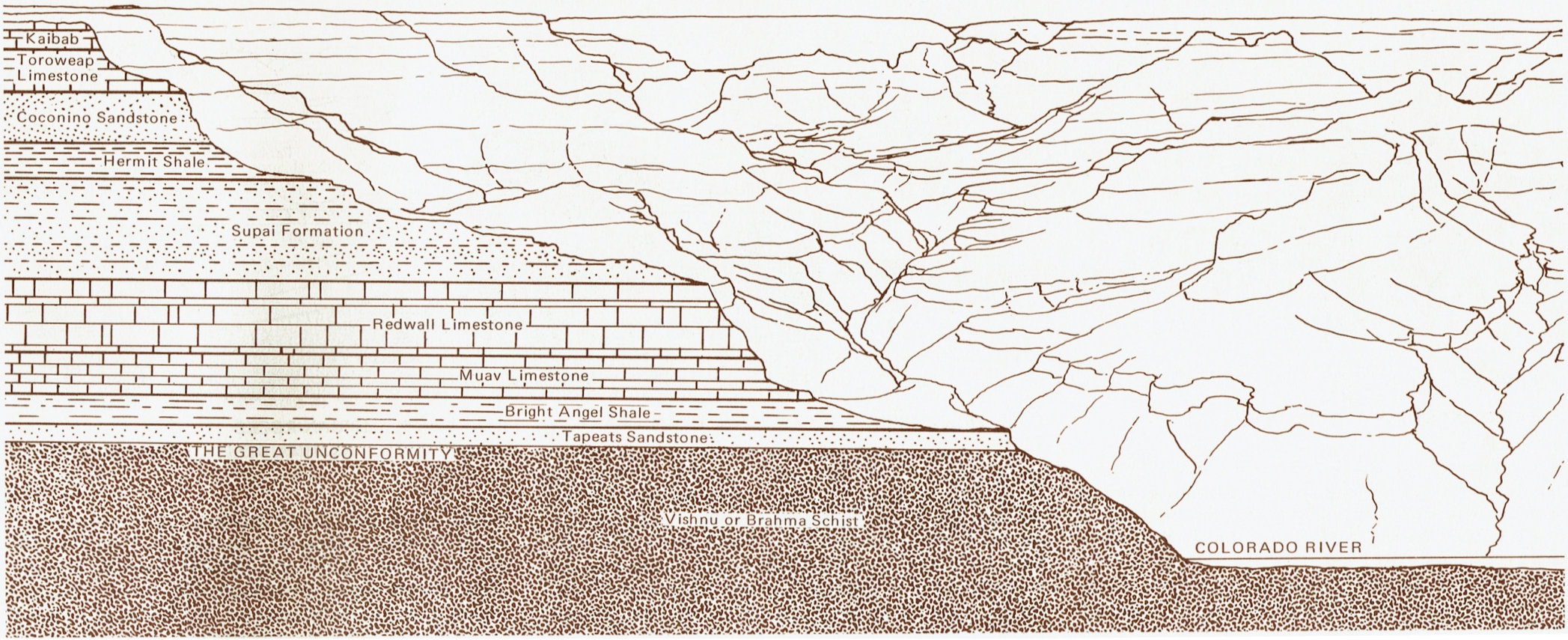
The Coconino Sandstone is the prominent white-colored cliff beneath the Kaibab and Toroweap Limestones. It is one of the most distinctive formations in the Grand Canyon and caps many buttes and temples in the National Park region. It is composed of fine quartz sand grains which are well rounded, pitted, or frosted, and show excellent sorting or sizing. The Coconino Sandstone is characterized by well-developed cross stratification, which is one of the most conspicuous features of the formation. The cross-strata consist of low, sweepingly inclined laminae, similar to that in the Navajo Sandstone in Zion National Park. Some of the laminae are as much as 70 feet long and are interpreted to have formed on the steep side of sand dunes.

At least 22 varieties of fossil tracks have been found in the Coconino Sandstone, all of which are interpreted to have been made by reptiles. The dune-like cross-stratification in the Coconino Sandstone, together with the reptile tracks and ripple marks, indicates that these sediments accumulated in a great desert. Its present distribution over an area of 32,000 square miles has led many geologists to postulate a depositional environment similar to that of the present-day Sahara or Arabian Deserts.

THE HERMIT SHALE AND SUPAI SANDSTONE (PENNSYLVANIAN-PERMIAN)

Beneath the white Coconino Sandstone is a sequence of interbedded red sandstones, siltstones, and shales approximately 1200 feet thick. In the National Park, the uppermost 200 or 300 feet is dominantly shale and forms a slope beneath the Coconino cliff. This formation is referred to as the Hermit Shale. The thick interbedded sandstone and shale below is called the Supai Formation. It responds to erosion by forming a series of steps with the sandstone beds developing nearly vertical ledges and the interbedded shales forming small slopes. The lowest slope of the Supai Formation, however, consists of interbedded impure limestone. Together these rocks are responsible for most of the red color seen on the Canyon walls.

A number of rare fossil plants and numerous tracks of four-footed animals have been collected from the Hermit-Supai rocks. The plants apparently represent a savanna-type environment with long, dry seasons. The sandstones and shales were evidently deposited in streams, floodplains, and deltas.



REDWALL LIMESTONE (MISSISSIPPIAN)

The Redwall Limestone characteristically weathers into an unbroken vertical cliff more than 500 feet high. It is the prominent cliff located almost midway between the river and the Canyon rim, and is responsible for many of the majestic alcoves, mesas, and buttes.

On fresh exposures the Redwall Limestone is light gray, but on weathered surfaces it is colored by a superficial red stain derived from the overlying formations. It is well bedded, but when viewed from a distance it appears almost as a single massive unit, because the subtle divisions between strata are not etched out in sufficient relief to be seen from the Canyon rim. The Redwall Limestone is a very pure calcium carbonate rock containing less than one percent sand and shale particles. It is susceptible to much solution activity by groundwater, and as a result, caves, solution caverns, arches, and springs occur in this formation. Found in the Redwall are shells, corals, and a wide variety of other marine life, most of it preserved in remarkable detail. These fossils, together with the pure nature of the limestone, indicate that the Redwall was formed in a broad, shallow sea.

THE TEMPLE BUTTE (DEVONIAN), AND THE MUAV LIMESTONE (CAMBRIAN)

The Temple Butte Limestone occurs only as small lenses at the base of the Redwall cliff, and is rarely seen from the Canyon rim. It is important geologically, however, in that it is bounded by 2 significant unconformities in the Paleozoic sequence.

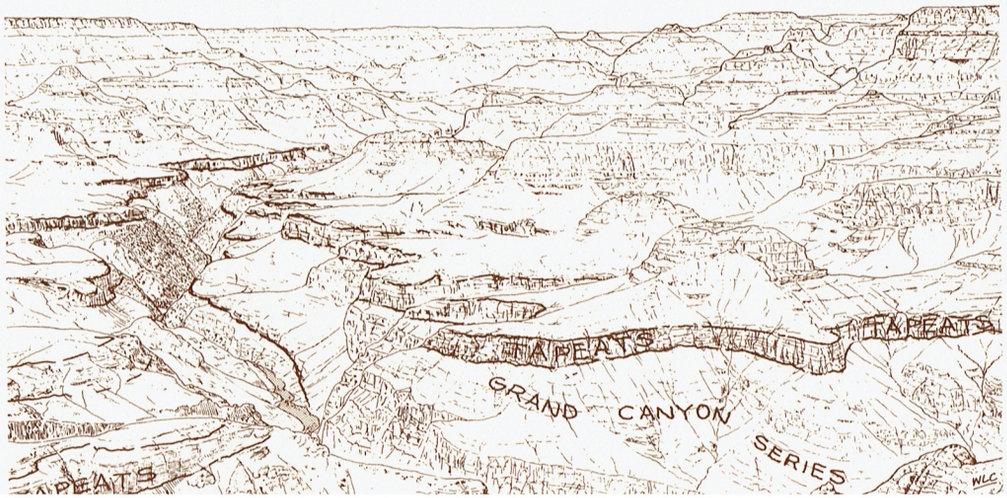
The Muav Limestone consists of a sequence of alternating gray limestone and greenish-gray calcareous siltstone. This formation characteristically erodes into 3 units. A basal cliff above the Bright Angel Shale is followed by a sequence of small ledges and slopes, which in turn is overlain by an upper cliff member nearly twice as thick as the basal unit. The Muav Limestone is greenish gray, and when seen at close hand is very thinly bedded.

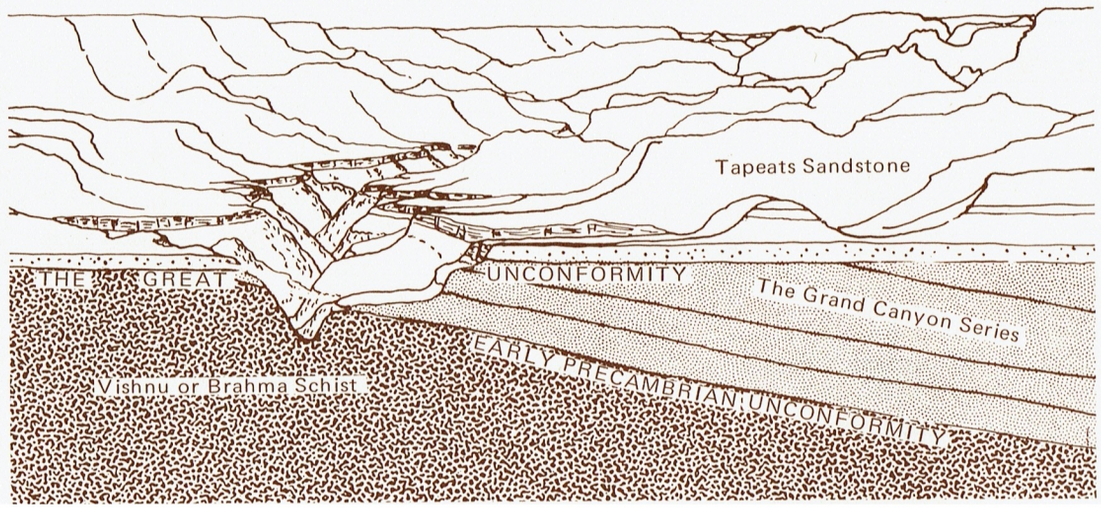
Fossil trilobites and ripple marks appear at various horizons within the Muav Limestone, and indicate a relatively shallow marine environment of deposition for the formation. It is the youngest Cambrian formation within the Grand Canyon.

BRIGHT ANGEL SHALE (CAMBRIAN)

A sequence of fine-grained, light green silty shale approximately 450 feet thick occurs beneath the Mauv Limestone and is referred to as the Bright Angel Shale. The shale is weak and susceptible to erosion, and as a result has been eroded back from the underlying Tapeats Sandstone to form a broad terrace known as the Tonto Platform. This terrace is one of the most significant topographic features seen in the National Park. It is approximately 3,000 feet below the Canyon rim and ranges up to 3 miles wide. It thus stands out in marked contrast to the steep V-shaped Granite Gorge below.

Three general types of fossils have been found within the Bright Angel Shale, all of which indicate it is of Cambrian age. Small, thin shells of extinct brachiopods are abundant, as are trilobites and many invertebrate fossil tracks and trails. The Bright Angel Shale is considered to be of marine origin, representing deposition of silty muds in a shallow sea environment.





TAPEATS SANDSTONE (CAMBRIAN)

The Tapeats Sandstone is the lowest Paleozoic formation in the Grand Canyon, and is one of the most persistent and prominent rock bodies. It is 200 to 300 feet thick and is easily recognized because it characteristically weathers into a vertical cliff immediately below the Tonto Platform.

The Tapeats Sandstone commonly weathers to a dark brown, but fresh surfaces are much lighter. It is composed mostly of coarse quartz sand grains, and like the Bright Angel Shale contains several varieties of marine Cambrian fossils. The Tapeats Sandstone can be traced through the entire Canyon with only a few interruptions. Where it overlies the Precambrian metamorphic rocks it presents a striking contrast in development of landscape, as it forms a continuous rampart on top of the V-shaped Granite Gorge. The contrast is somewhat less obvious, however, where it overlies the gently dipping sedimentary rocks of the Grand Canyon Series.

LATE PRECAMBRIAN ROCKS – THE GRAND CANYON SERIES

A thick sequence of fine-grained sandstone, siltstones, and shale which have been tilted at angles ranging up to 15 degrees, is exposed as isolated remnants in the Park area. These rocks stand out in marked contrast to the overlying horizontal Paleozoic strata and are referred to as the Grand Canyon Series. They exist in isolated wedges, and have not received the same attention as that given the overlying Paleozoic units. The Grand Canyon Series is remarkable in that it represents an accumulation of silt, shale, and sandstone over 12,000 feet thick, with little variation in rock type. These rocks are typically nonresistant and where considerable thicknesses of the series are exposed, such as in the area below Desert View, the Canyon floor is characterized by an open valley with rolling hills.

The Grand Canyon Series is divided into 2 groups of rocks. The upper, or Chuar Group, is seen from Point Imperial and Cape Royal on the North Rim. The lower, or Unkar Group, is exposed at the bottom of the Canyon in the east end of the Park, and can be seen in isolated outcrops in the vicinity of Phantom Ranch. The Unkar Group is subdivided into the following formations listed from oldest to youngest: (1) Hotauta Conglomerate; (2) Bass Limestone; (3) Hakatai Shale; (4) Shinumo Quartzite; (5) the Dox Formation, which forms the great bulk of red shale and siltstone overlying the Shinumo Quartzite; and (6) the Nankoweap Formation.

EARLY PRECAMBRIAN ROCKS VISHNU SCHIST, BRAHMA SCHIST, AND ZOROASTER GRANITE

The oldest rocks within the Grand Canyon are exposed within the Granite Gorge and are characteristically dark in appearance. They erode to form a steep-walled, V-shaped gorge through which the Colorado River flows. These dark colored rocks are highly deformed and have been subjected to intense heat and pressure and to the effects of fluids and gases. The original sedimentary or volcanic character of these rocks has been extensively modified and in some cases obliterated. Early Precambrian rocks are not stratified but possess a structure known as *foliation* resulting from the parallel arrangement of platy minerals, crystals, and grains. Foliation throughout most of Granite Gorge is nearly vertical, which contrasts with the horizontal stratification of the overlying younger rocks.

Three major rock bodies are found within the Early Precambrian complex. In the vicinity of Phantom Ranch, the Brahma Schist consists of baked and altered volcanic rocks in which few if any relic structures are preserved.

The Vishnu Schist appears similar to the Brahma Schist when viewed from the Canyon rim, but consists of metamorphosed sedimentary rocks. Numerous granitic dikes have intruded into both the Vishnu and Brahma schist, most of which are nearly vertical and are parallel to foliation.

Large granite bodies of the Inner Gorge are referred to as the Zoroaster Granite, and represent a period of igneous activity after deposition and metamorphism of both the Brahma and Vishnu Schists, but before deposition of the overlying Grand Canyon Series and Paleozoic formations.

COLOR IN THE CANYON

One of the most esthetically rewarding features of the Grand Canyon is its infinite variety of color. The tone and intensity of hues are to a considerable degree dependent upon the effects of lighting. At times of overcast or where there is strong back lighting, the Canyon may appear to be hazy violet, but with special lighting effects such as at sunset, the entire Canyon appears ablaze with red or orange. Under normal lighting conditions on a clear day, the many colors of the rock layers are distinct, and the intrinsic colors of the Canyon are relatively simple, with tones of red, green, black, brown, white and gray dominating. Iron is the dominant coloring agent in rocks, and is responsible either directly or indirectly for most tones of red, green, black and brown. Organic matter produces various tones of gray, and the white is a result of the colorless nature of quartz.

Red

The red color in the sandstones and shales of the Hermit and Supai formations and the Grand Canyon Series is the result of finely divided particles of the mineral hematite dispersed through the rock. Hematite is an iron oxide which is typically deep red, and a small amount will impart a rich red color to the entire formation. The tone depends on the amount of hematite present, which is in turn controlled to a large extent by the pore space and grain size. Fine grained shales are commonly a deeper red than coarser sandstones. Hematite from the Hermit and Supai formations is responsible for the color of the Redwall Limestone; it is washed over the surface of the Redwall cliff and stains the light gray limestone deep red.

Green

Ferrous iron produces tones of blue, green or white and most rocks containing ferrous iron instead of hematite will be colored various shades of green. The Bright Angel Shale is greenish because of the ferrous iron which probably resulted from reducing conditions in the ancient sea in which it accumulated.

Black

Many minerals in metamorphic rocks are dark green or black because they contain large amounts of iron. The abundance of these minerals in the Vishnu and Brahma schists produces the dark green to black hues in the Granite Gorge.

Brown

Limonite, a common iron oxide, is characteristically brown or buff in color. It occurs in many sandstones such as the Tapeats, and where it is abundant it imparts a deep brown color to the rock even though over 95% of the mineral grains are colorless quartz. Small amounts of limonite stain the rock yellowish brown.

Gray

The gray to buff color of the Kaibab and Toroweap limestones is due to varying amounts of finely divided carbonaceous matter. Shales and limestones are particularly susceptible to the coloring effects of this material, and will produce tones ranging from light gray to black.

White

The Coconino Sandstone is composed of 99% colorless quartz grains with little iron or other impurities. The rock is therefore essentially white, although locally it may be buff to yellowish brown because of small amounts of limonite.

Color Produced by Vegetation

The Ponderosa and pinyon-juniper forests on the canyon rim impart a dark green cast to much of the upper part of the Canyon wall, but do not significantly influence the color of the Canyon below the Hermit Formation. The lower part of the Canyon may appear at first glance to be devoid of vegetation, but desert shrubs are uniformly though sparsely distributed over much of the Tonto Platform, and impart a speckled green tone to this surface.

Agave or "century plant." Although superficially resembling yuccas of the Lily family, the agaves actually belong to the Amaryllis family. Seen most frequently in the inner Canyon, they are also prominent on drier areas of the Canyon rim such as at Point Sublime and Toroweap Valley.

SOME IMPORTANT FEATURES OF THE CANYON

Redwall Cliff

The Redwall Limestone, forming a vertical wall averaging 550 feet in height, is located approximately midway between the Canyon rim and the Colorado River. The cliff, stained red from the overlying Supai and Hermit formations, is nearly continuous and can be traced zig-zagging around lateral chasms, surrounding majestic alcoves, and encircling mesas and buttes. It extends throughout the entire Canyon, and is one of the most conspicuous topographic features in the Park.

Alcoves

The Redwall cliff commonly responds to erosion to form great alcoves. These are especially well developed at the head of minor tributaries and commonly form recesses or caverns with an overhanging cliff. Reference to the topographic map will show a striking contrast between the acute gully-like notches in the tributaries cut in the Tapeats and the semi-circular alcoves in the valley heads cut in the Redwall Limestone.

Caves

Solution activity of ground water has formed a number of caves in the major limestone units such as the Kaibab and Redwall formations. The caves are generally too small to be impressive when viewed from the Canyon rim, but some can be seen from the South Rim at Yavapai Point. Springs issue forth from many of the caves on the North Rim, especially during wet seasons. An excellent example is Cheyava Falls on the west side of Walhalla Plateau (see p. 27).

Amphitheaters

Headward erosion of streams tributary to the Colorado River has cut back large amphitheaters into the Canyon wall. These are best developed on the North Rim because erosion is accelerated by the greater elevation, increased precipitation, and the drainage of the Kaibab Plateau toward the river. The amphitheaters, or tributary canyons, are as much as 15 miles long, 3-4 miles wide, and 5000 feet deep.

Temples

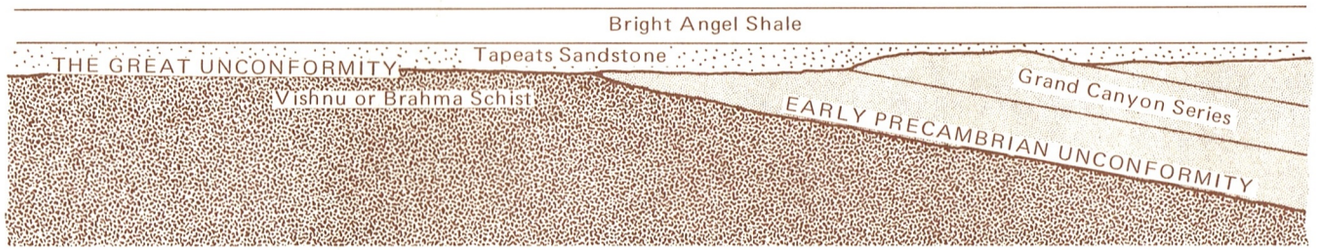
Headward erosion of tributary valleys has isolated segments of the main plateau to form detached mesas. As the mesas diminish in size, they become small buttes which stand up above the surrounding surface in the form of a pyramid or *temple.* These erosional features are capped by the more resistant rocks such as the Kaibab, Coconino, or Redwall formations. They are best developed on the north wall, and are responsible for much of the scenic grandeur of the Canyon.

Tonto Platform

The Tonto Platform is a broad terrace carved on top of the Tapeats Sandstone 3000 feet below the Canyon rim. The terrace is commonly more than a mile wide and extends throughout most of the National Park area. It develops as the weak Bright Angel Shale is stripped away from the resistant Tapeats Sandstone, which forms the ramparts of the Granite Gorge.

The Granite Gorge

The Granite Gorge is the narrow V-shaped inner chasm cut by the Colorado River in resistant metamorphic and igneous rocks. It extends from Grandview Point downstream to the vicinity of Powell Plateau, a distance of 40 miles. The Middle Granite Gorge, further downstream and west of Powell Plateau, is 4 miles long. In the western Canyon the Lower Granite Gorge is some 50 miles long, and extends almost to the Grand Wash Cliffs. As seen from the developed rim points, the Granite Gorge is approximately 1300 feet deep and is characteristically dark somber gray. It erodes into a ragged steep slope, and thus stands out in marked contrast to the colorful alternating cliffs and slopes of Paleozoic rocks which form the high Canyon walls.

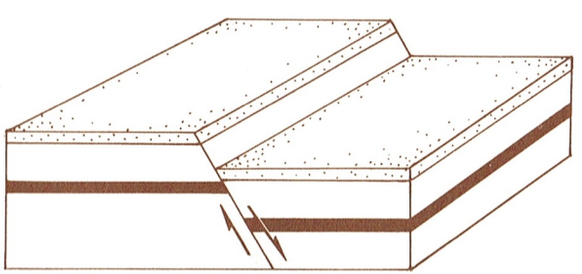


The Major Unconformities

The most significant boundaries between rock bodies in the Canyon are the two major unconformities which separate the rocks into three principal groups. An unconformity is a surface of erosion or nondeposition which separates younger strata from older rocks. It represents a significant discontinuity in the rock sequence, and commonly there is a structural discordance between the rock bodies that indicates interruption in the rock-forming processes. Older rocks show evidence of deformation and erosion prior to deposition of the younger sequence.

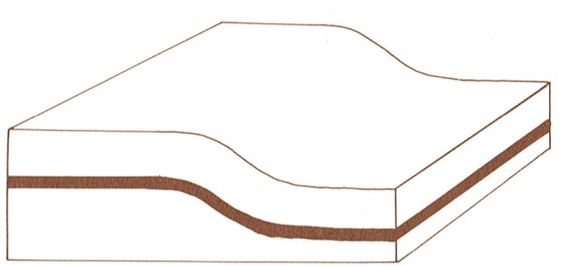
The Great Unconformity in the Grand Canyon can be traced throughout much of the Park area. It separates the horizontal Paleozoic rocks which form most of the Canyon walls from the deformed underlying Precambrian rocks. In the central and western part of the Park, the Great Unconformity appears as a straight horizontal line at the base of the Tapeats Sandstone, beneath which is the V-shaped Granite Gorge. Rocks in the Granite Gorge were twisted and deformed by earth movements, intruded by granite, and extensively eroded prior to the deposition of the overlying horizontal strata. From the Canyon rim the Great Unconformity appears to have little relief, but ancient hills as much as 800 feet high are covered by the overlying sediments. In the eastern part of the Canyon the Great Unconformity separates the tilted strata of the Grand Canyon Series (see page 8) from the horizontal Paleozoic rocks. Excellent exposures of the Great Unconformity can be seen from both sides of the Canyon.

An Early Precambrian Unconformity separates the tilted strata of the Grand Canyon Series from the underlying metamorphic rocks and is similar in most respects to the younger Great Unconformity. It is, however, tilted to the east and is well exposed in only a few places. Excellent views of this older erosional surface can be seen from Grandview, Lipan, Desert View and Cape Royal.



Faults

A fault is a fracture in the rock sequence along which displacement has occurred. A number of faults have dislocated the strata in the Grand Canyon and represent important periods of deformation. Faults have also exerted significant control on the erosional development of tributaries, and the isolation of mesas and buttes. Most of the faults displace the strata 50 to 200 feet, so that the casual observer may fail to recognize them. Two excellent examples are the Bright Angel fault, which controls the development of the straight tributary of Bright Angel Canyon, and the Muav fault, which separates Powell Plateau from the North Rim.



Monoclines

Monoclines are simple flexures which form a step-like bend in otherwise horizontal or gently dipping strata. One of the most significant flexures in the Grand Canyon is the East Kaibab monocline, which elevated the Kaibab Plateau 2000 - 3000 feet above the Marble Platform to the east. Trending northwest through Grandview Point is a smaller monocline, along which the strata are displaced 500 feet.

THE COLORADO RIVER

The Colorado River is one of the major river systems in North America. It drains the eastern flanks of the Southern Rockies in Colorado, and the upper tributaries reach northward into the Wind River Mountains of Wyoming. Essentially all of the Colorado Plateau is drained by the Colorado River system, the major tributaries being the Green River and San Juan River of Utah and the Gila River in Arizona. The Colorado River empties into the Gulf of California near Yuma, Arizona, where it has constructed a huge delta.

In contrast to most other major rivers, the Colorado has an exceptionally steep gradient. In the Grand Canyon area the river falls from an elevation of 3090 feet at the Echo Cliffs to 870 feet at Lake Mead. The average gradient is approximately 7.7 feet per mile, or more than 25 times that of the Mississippi River.

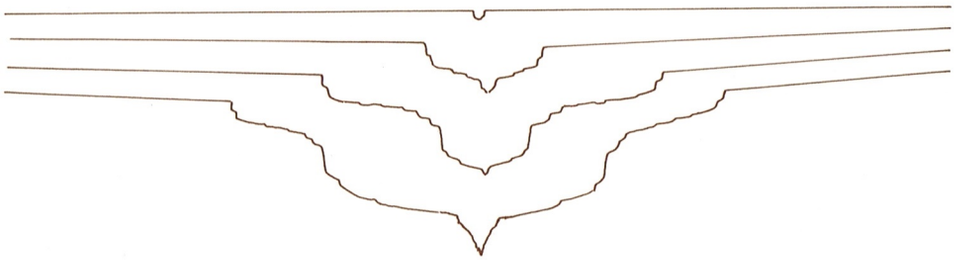
Before construction of the Glen Canyon Dam the river had a discharge ranging from 1,300 to 200,000 second feet of water. Depth of the river averages 50 feet, and widths of 300 to 400 feet are common. The water of the Colorado River is generally very silty, especially after storms or during spring runoff.

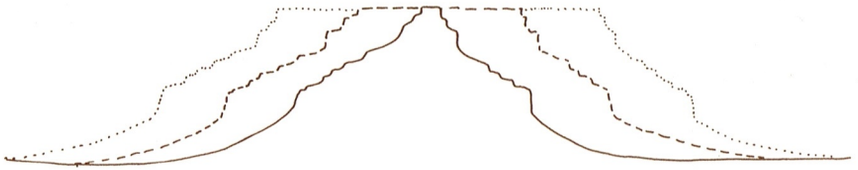
Rapids

Rapids in the Colorado River are among the most vigorous in the world. There are 161 rapids in the Grand Canyon region, several of which can be seen from view points on the South Rim.

The Rapids are not produced by resistant rocks projecting above the general gradient of the streams as is the case in most rivers, but result from huge boulders brought down by tributary streams during flash floods.

The size of the rapids varies somewhat from year to year with the amount of debris which accumulates at the mouth of the tributary. In December, 1966 an abnormally intense cloudburst on the North Rim caused flash floods to occur along Bright Angel Creek and Crystal Creek, several miles on downstream. The debris brought into the gorge greatly modified and intensified the rapids. Some rapids can thus be drastically altered after a single storm, while others may be little affected over a number of years. Erosion by the Colorado River then wears down the removed debris with a tendency toward obliterating and smoothing out the irregularities in gradient which cause the rapids. This, however, is seldom if ever accomplished because new material is usually brought in before the older debris can be entirely removed.





The evolution of the Canyon landscape is shown diagramatically in the accompanying figures. In the early stages of development the Canyon was deepened, and branching tributaries developed new valleys. Faults produced zones of weakness along which erosion was accelerated. The Kaibab Limestone maintained a flat plateau surface and the Canyon was widened as the cliffs retreated. Resistant sandstone and limestone formations formed nearly vertical cliffs which were maintained by constant undermining of the weak nonresistant shales beneath. This produced the step-like profile of the Canyon wall. Headward erosion along tributary valleys produced peninsula-like landmasses extending out into the Canyon from the main plateau. An excellent example of this stage of erosion is the Walhalla Plateau, which is connected to the Kaibab Plateau by a narrow isthmus at the head of Bright Angel Creek. A mesa is formed when headward erosion succeeds in isolating the promontory from the main landmass. Powell Plateau is in this stage of development, as it is completely cut off from the Kaibab Plateau by erosion of two tributaries along the Muav fault zone.

A new mesa is bounded on all sides by steep cliffs of the Kaibab Limestone. As the mesa shrinks in size by wastage of its surrounding cliffs, it assumes the form of a high flat-topped hill or butte. In the Grand Canyon these prominent buttes are commonly referred to as temples. Further erosion will reduce the butte to a pinnacle such as Mt. Hayden, and ultimately the resistant cap rock is completely removed. Underlying weak shales are quickly eroded away and a new cap rock is formed on the next lower resistant sandstone or limestone. An excellent example of this is Cheops Pyramid, west of Phantom Ranch.

The cross-cutting fault systems have played an important part in the development of temples or buttes on the North Rim, as they provide a crisscross network of linear zones of weakness along which erosion accelerates to isolate a mesa or small plateau.

The hard resistant metamorphic and igneous rocks in the bottom of the canyon are relatively homogeneous, and respond to erosion to form a narrow V-shaped gorge.

BIOLOGICAL SETTING

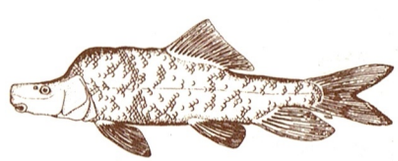
The Grand Canyon district presents a wide variety of life forms and environmental conditions which have been subjects for study on the part of biologists since the days of early exploration. Most portions of the Colorado Plateau are considered high or cool deserts; these are characterized by warm, dry summers and cold, almost equally dry winters. Snowfall is scanty over much of the area, with the majority of the precipitation occurring as rain resulting from summer thundershower activity. The desert conditions at these medium elevations of the Plateau are therefore not so much a consequence of continuously warm temperatures as they are the result of poor moisture availability year-round.

Extremes in elevation prevail on the Colorado Plateau, and these of course provide for greater climatic diversity. The high peaks of the mountain ranges on the Plateau, some in excess of 12,000 feet above sea level, are countered by the lower reaches of the Grand Canyon, at elevations less than 1,000 feet. This altitudinal difference has obvious consequences for animal and plant distribution; there is little resemblance between the flora and fauna of the mountain coniferous forests and that of the arid inner canyon.

Considerations such as these led to the formulation of some pioneer ecological theories dealing with biological distribution at the Grand Canyon. Chief among these was the "life zone" concept of C. Hart Merriam, proposed in the 1890's. Merriam, an experienced field biologist with the U.S. Biological Survey, was impressed by the apparent effects of mean temperature in controlling the distribution of natural communities. Specifically, he postulated that the northernmost distribution of any species was limited by the total quantity of heat during the season of growth and reproduction, while the southernmost points of its range would have limits imposed by the mean temperature of a brief period during the hottest part of the year. In his opinion, these effects were well expressed in the belt-like zonation of plants and animals on mountains, a pattern which led to the creation of the "life zone" diagrams frequently used in Grand Canyon literature and biological publications in general. The captions for such diagrams usually explain that habitat conditions and life forms in the bottom of the Canyon approximate those of the low-elevation Sonoran deserts of southern Arizona and northern Mexico. One may then ascend the Canyon walls and into the nearby San Francisco Mountains through more or less distinctive "layers" of biological communities.

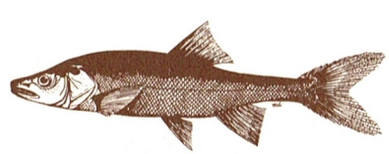
From this developed the familiar statement that in the relatively short distance from the Canyon depths to the tops of the San Francisco Peaks one would traverse habitat conditions comparable to those encountered on a journey from the northern part of Mexico to the Alaskan tundra. This is an obvious oversimplification, owing largely to the fact that the zones were selected on temperature criteria alone. Ecologists have since pointed out that there are a host of other factors – among them moisture relations, slope exposure, soil types, light, wind, and evaporative power of the air – which are equally influential in determining distribution of plants and animals. While the life zone concept still has some utility in calling attention to the different types of communities which develop in response to environmental gradients, its rigid application is no longer justified. Organisms respond to a complex of interacting physical, chemical, and biological factors; these seldom promote neatly-layered and sharply delimited zones, as even a brief observation of conditions at the Canyon will reveal.

Native fishes of the Colorado River.
see discussion, page 33

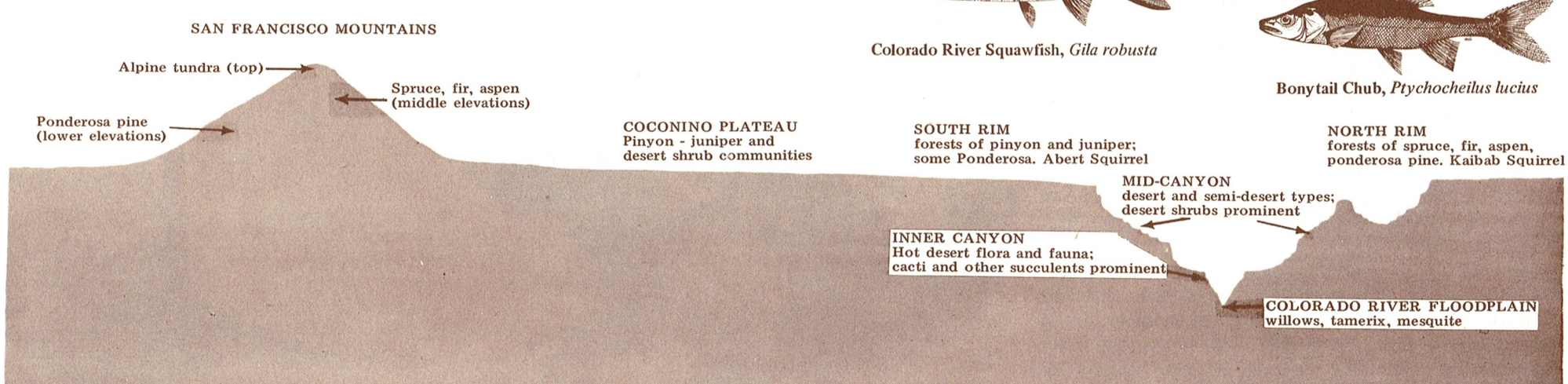


Humpback Sucker, *Xyrauchen texanus*

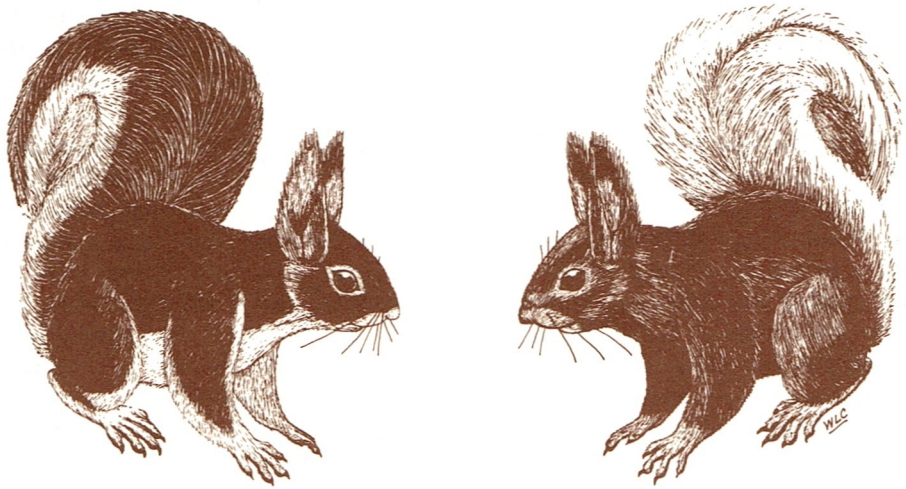
Colorado River Squawfish, *Gila robusta*



Bonytail Chub, *Ptychocheilus lucius*



Generalized zonation of life forms in the Grand Canyon and adjacent plateaus and mountains.

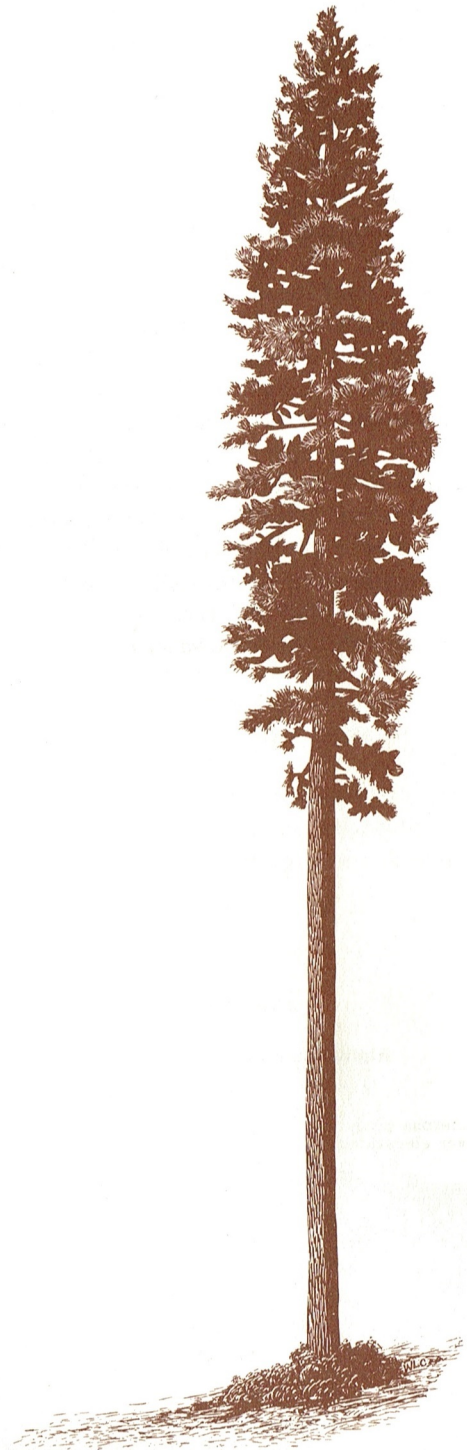


At right, the Kaibab Squirrel, *Sciurus kaibabensis,* (white tail, rusty back), confined to the Kaibab Plateau, and (left) its close relative the Abert Squirrel, *Sciurus aberti,* (light belly, dark tail).

Another aspect of Grand Canyon biology which early caught the attention of field workers was the phenomenon of the Canyon as a geographic and ecological barrier to animal distribution. The essence of this idea is that topographical and environmental changes through time have resulted in the isolation of populations of animals, which have subsequently undergone some genetic diversification, so that today they differ to some extent from the ancestral parent stock. It should be emphasized that this isolation is not necessarily geographic; ecological or habitat isolation can be equally profound. While there are published studies dealing with numerous groups of animals having related forms on opposite sides of the Colorado River, the most famous and enlightening example is that of two species of tassel-eared squirrels. The Kaibab Squirrel *(Sciuris kaibabensis)* is found only in relatively restricted areas of the Kaibab Plateau, north of the Canyon. It is isolated both by the geographic barrier of the Canyon to the south, and by the ecological barriers provided by desert-like conditions that surround the Kaibab Plateau on the other three sides. It evidently represents a remnant of an ancestral population of tassel-eared squirrels which occupied the entire Grand Canyon region at a time when ecological conditions were more optimum for it. The closely related Abert Squirrel *(Sciurus aberti)* is more widely distributed in medium to higher elevations throughout the southwest, including portions of the South Rim, a scant ten miles or less in airline distance from the Kaibab form. There are minor morphological differences between the two species (see above); these, along with genetic and ecological evidence, seem to indicate that the two may indeed be separate species.

The Kaibab Squirrel is also an excellent example of a species with a very restricted distribution. Both forms are ecologically "tied" or dependent upon the Ponderosa Pine forests, although the Abert Squirrel appears to be somewhat more versatile in this respect, and is occasionally found in the adjacent pinyon - juniper communities. The Ponderosas furnish food (pine seeds and the inner bark of terminal twigs, as well as mushrooms associated with the roots of the pines), nesting sites, and cover for the squirrels. So complete is the dependence of the Kaibab Squirrel on the Ponderosas that a map showing the distribution of these pine forests on the Kaibab Plateau is also a plot of the areas where Kaibab Squirrels are likely to occur. Since most of the acreage of Ponderosa Pine is actually outside the boundaries of the National Park, it would appear that continued survival of this interesting animal will depend upon wise management practices in the Kaibab National Forest.

Detail of cone, seeds, and needles of Ponderosa Pine.



Ponderosa or Yellow Pine, *Pinus ponderosa,* common on both rims.

Pinyon Pine, *Pinus edulis,* which, with Utah Juniper, covers most of the Coconino Plateau and lower slopes of the Kaibab Plateau.

Utah Juniper, *Juniperus osteosperma.*

Detail of needles and berry-like cones of Utah Juniper.

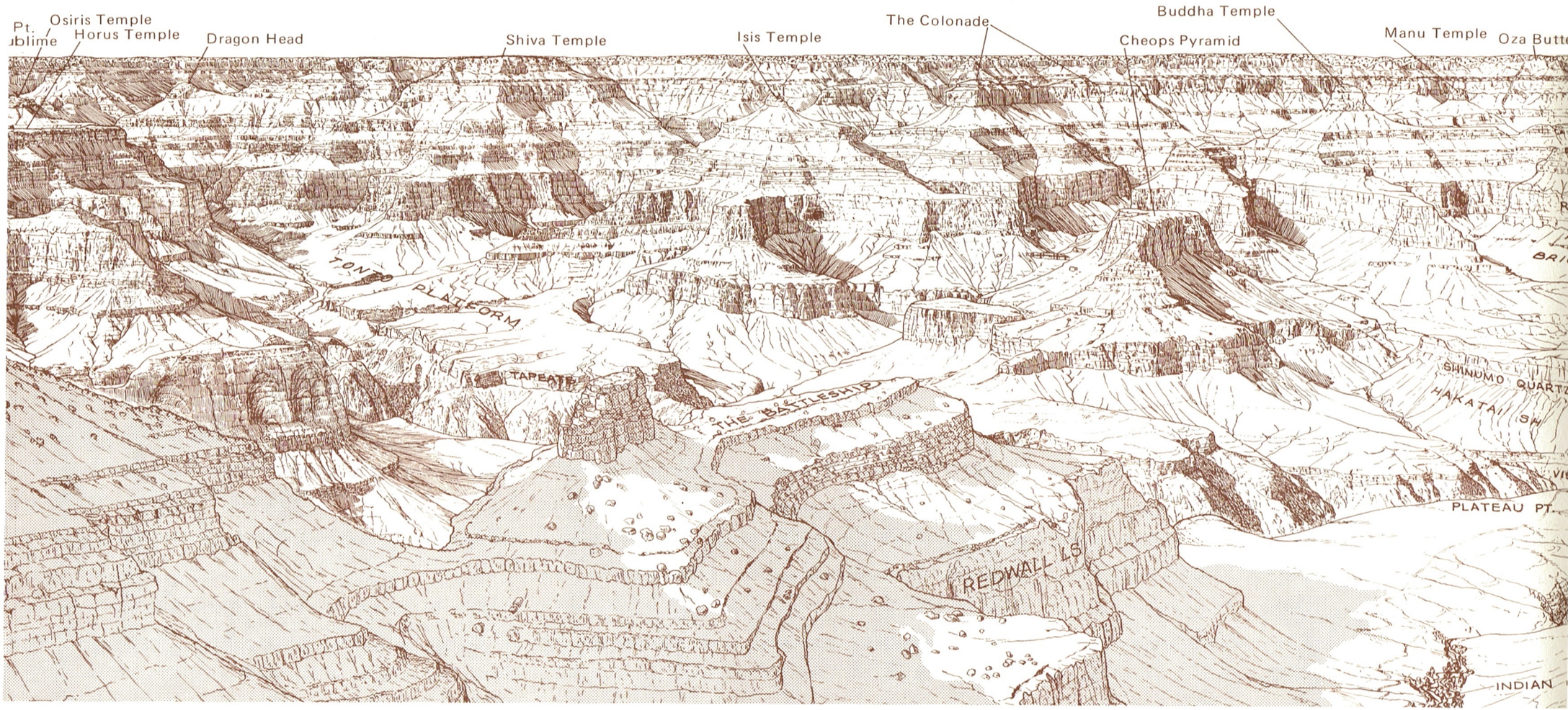
Detail of cone, seeds, and needles of Pinyon Pine.

The beautiful Kaibab forest is also a subject of ecological interest as well as esthetic appeal. The dominant trees are stands of aspen, spruce, Douglas-fir, and Ponderosa Pine, with intervening meadows which frequently afford observations of mule deer and other wildlife. Space limitations will not permit discussion of the valuable lessons in management of wildlife and other resources which have been learned through experience, often bitter, in this famous forest; the reader is urged to consult the interpretive exhibits along the highway for further details.

Big Sagebrush, *Artemesia tridentata.*

Golden-mantled Ground Squirrel, *Citellus lateralis.*

Mormon Tea or Jointfir, *Ephedra viridis.* Indians, as well as early Mormon settlers, brewed a tea for medicinal purposes from the "leafless" foliage of this plant.



EL TOVAR

Location: The Canyon Rim at Grand Canyon Village.

Elevation: 6860'

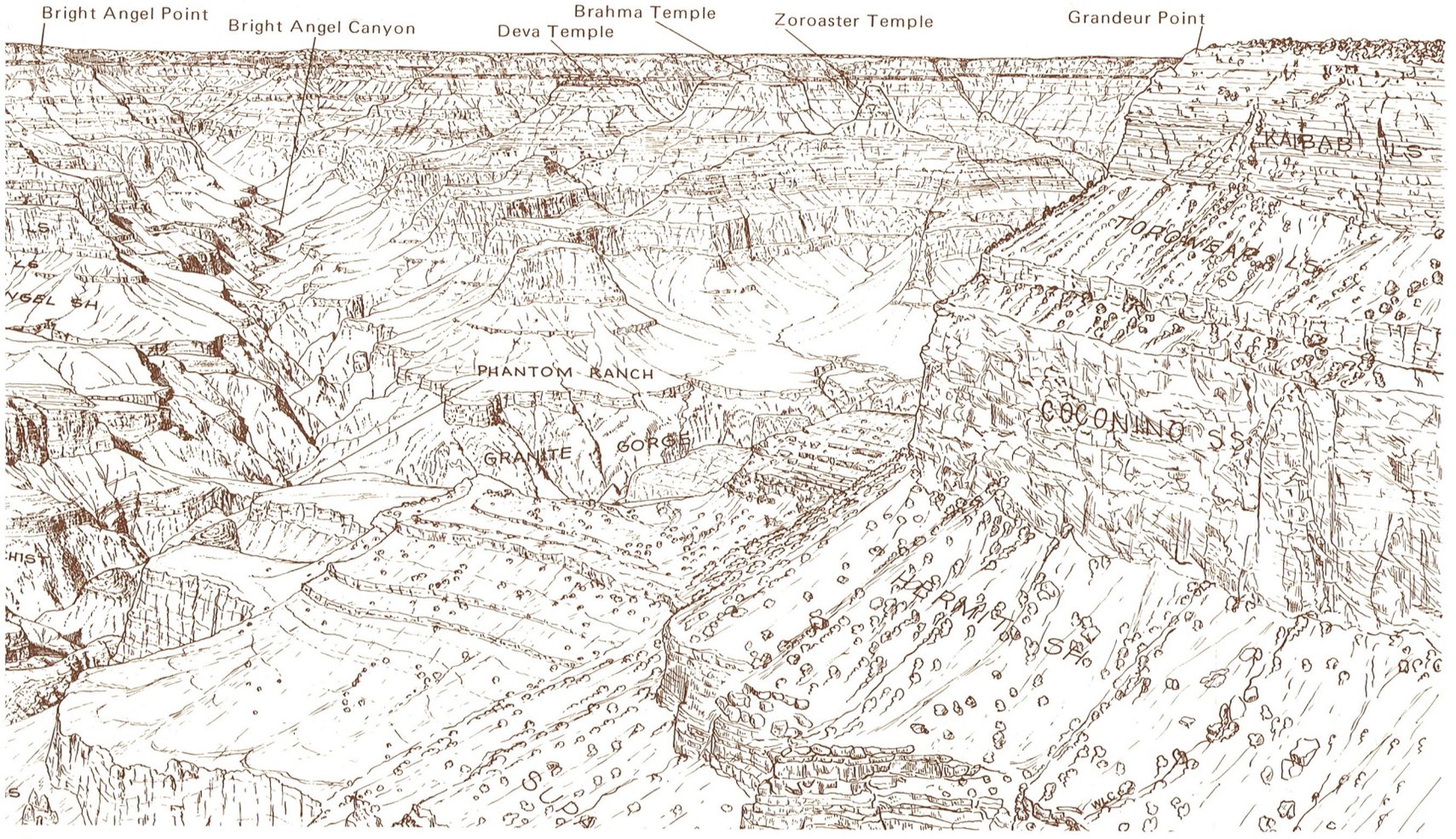
The view from the terraces of Bright Angel Lodge and El Tovar Hotel presents a panorama looking northward up the long straight tributary valley cut by Bright Angel Creek. This view is probably seen by more people than any other part of the Canyon, and although it is not one of the larger panoramas, three major features are well displayed: (1) the Bright Angel fault and its influence on the development of the valley of Bright Angel Creek, (2) the wedge of Precambrian Grand Canyon Series which protrudes above the level of the Tapeats Sandstone and the Tonto Platform, and (3) the upper part of the Granite Gorge. The Colorado River at the bottom of the Gorge cannot be seen from this area.

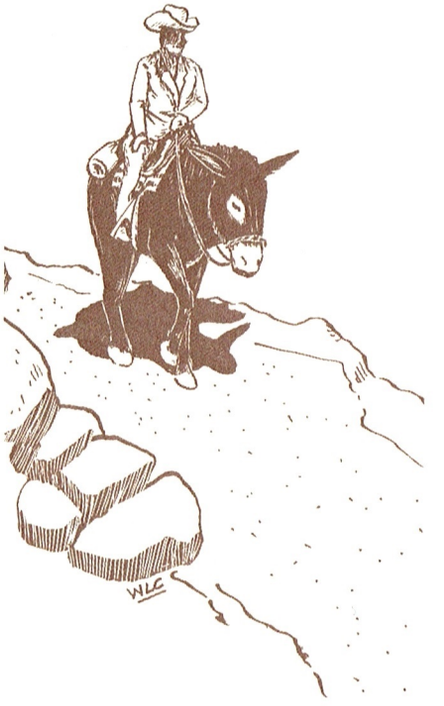
The Bright Angel Fault

The Bright Angel fault is a major structural feature in this part of the Canyon; as seen from the geologic map, it trends in a northeast direction across the Canyon and the plateau beyond. The Kaibab, Toroweap, and Coconino formations have been offset 185 feet. The fault trends northward up Bright Angel Creek, and displacement of the Tapeats Sandstone is clearly seen about midway up Bright Angel Canyon. Complex movement along the Bright Angel fault occurred before the horizontal Paleozoic formations were deposited, as is evidenced by the deformed strata of the Grand Canyon Series on the rim of the Granite Gorge near the mouths of Bright Angel Creek and Garden Creek. The Bright Angel fault is an inherent zone of weakness, and is responsible for the development of the abnormally long straight valley of Bright Angel Creek as well as the Garden Creek reentrant, which represents the continuation of the fault on the South Rim.

Grand Canyon Series

Across the river and directly north of El Tovar is a large wedge of Precambrian sediments which are part of the sequence of rocks known as the Grand Canyon Series. These rocks, lying just above the Granite Gorge, are easily distinguished by their red to reddish-brown color. In contrast to the younger horizontal Paleozoic rocks above them and the older vertical metamorphic rocks below them, the strata of the Grand Canyon Series are tilted up to 10 degrees. These rocks underlie the prominent butte known as Cheops Pyramid. Tracing the outcrop of the Tapeats Sandstone in this region, it soon becomes apparent that some of the rocks of the Grand Canyon Series, especially the hard cliff-forming Shinumo Quartzite, actually protrude up through the lower Paleozoic rocks. As a result, the Tapeats Sandstone and part of the Bright Angel Shale pinch out along the margin of this body of rock. It is clear from this relationship that the





Grand Canyon Series stood up as an island during the time the first Paleozoic seas entered this area and was not covered until after the Tapeats and part of the Bright Angel Shale had been deposited.

Granite Gorge

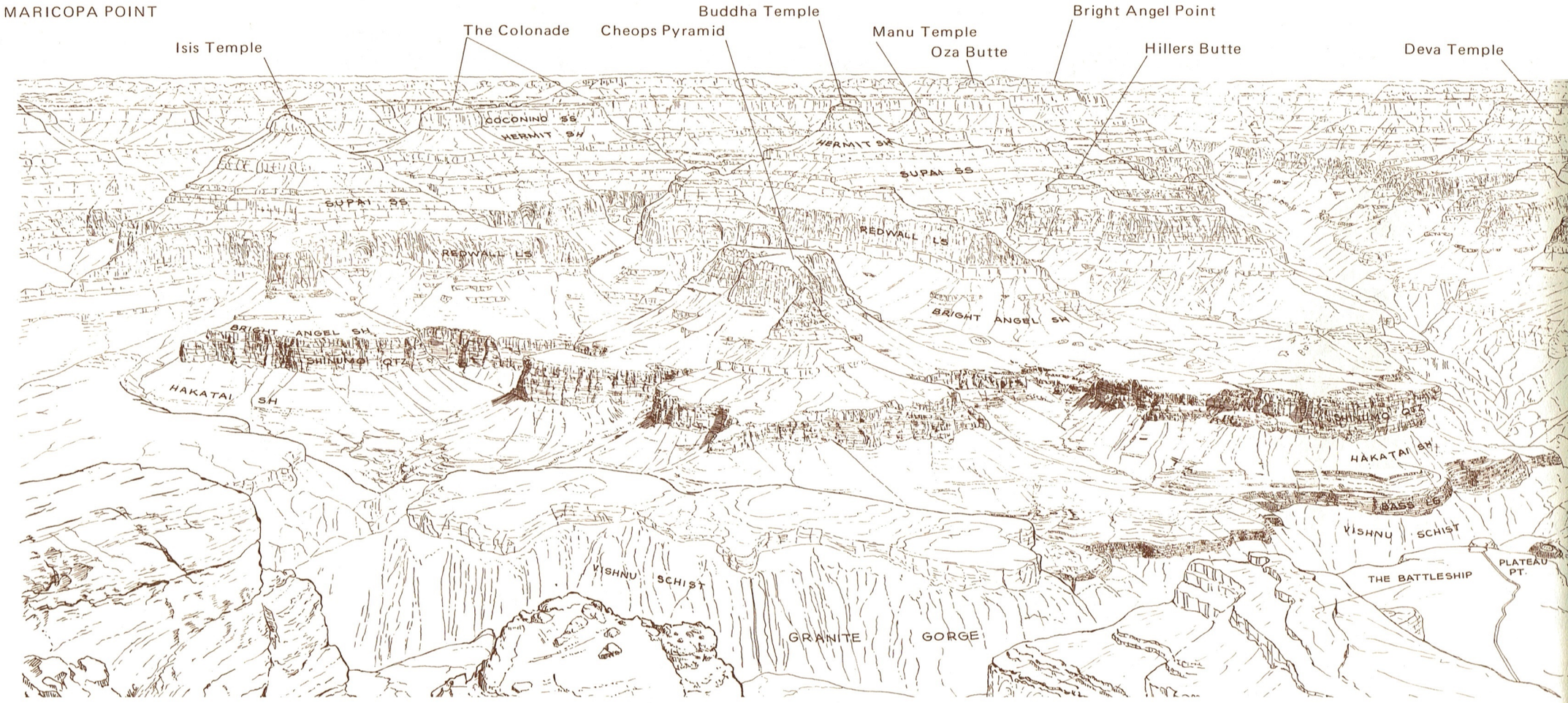
The Granite Gorge is well exposed throughout most of the canyon of Bright Angel Creek and the inner gorge of the Colorado River. In the vicinity of Bright Angel Creek the Granite Gorge is some 1300 feet deep, so that the Colorado River itself is not visible from El Tovar. Numerous dikes of pink granite intrude the metamorphic rocks of the Granite Gorge, and are especially abundant upstream from Bright Angel Creek. The prominent trail leading to Plateau Point from Indian Gardens was built for the express purpose of permitting visitors on mule trips to view the Granite Gorge and the river below.

Ecology

Owing to concentrated human activity, the much-visited area in this vicinity presents a greater degree of ecological disturbance than is apparent at other rim points. This incidentally emphasizes the dilemma of National Park Service administrators who are charged with protecting natural features from human disturbance and at the same time making them accessible to public visitation.

The pinyon-juniper communities, characteristic of much of the South Rim, extend out onto the adjacent points. The condition of the forest communities below the rim, however, provides a striking example of the effects of slope exposure and its accompanying habitat differences. Note, for instance, that on the west facing slopes adjacent to Grandeur Point the pinyons and junipers extend down a vertical distance of 2000 feet to the top of the Redwall. On the east and north facing slopes of the amphitheater extending on around west to Maricopa Point, the situation is markedly different. Here the combination of increased shade, cooler temperatures, and greater retention of soil moisture favors the growth of larger conifers, notably Douglas-fir, at elevations well below the rim. In late winter, patches of snow persist in shaded areas below the South Rim long after it has disappeared on west and south facing slopes, including those of the higher North Rim on the opposite side of the Canyon. These modifying influences produce a situation wherein a type of vegetation requiring more moisture is found growing below the drier communities of the rim. Thus local microhabitat conditions are altered sufficiently to permit this type of community to exist where it would not otherwise be expected.

This viewpoint also provides an excellent view of the Garden Creek drainage immediately below, with the conspicuous groves of trees at Indian Gardens especially prominent. The majority of these trees are planted cottonwoods, *Populus fremontii,* which furnish shade for the trail camp and "mule stop" here, and provide an oasis for mammal and bird activity. Until the transcanyon water line is completed, the entire water supply for the South Rim is pumped up from Indian Gardens.



MARICOPA POINT

Location: 3.2 miles west of the Visitor Center on the West Rim Drive.

Elevation: 7050'

Immediately west of Grand Canyon Village, a large promontory projects well out into the Canyon; reference to the map (p. 48) will indicate that this projection occupies the area between the Garden Creek reentrant and the Abyss. Several of the better known views of the Canyon are obtained from points along the West Rim Drive as it parallels the contour of this promontory. They are, in sequence: Maricopa, Powell, Hopi, and Mohave Points. Maricopa Point is the first of these viewpoints which permit close examination of the section of the Canyon west of Bright Angel Creek. Hopi Point is undoubtedly the most renowned of this group, and from the standpoint of esthetics the view from Hopi is not easily surpassed. For purposes of interpretation, however, we feel that the similar views from Pima Point and Maricopa Point provide the best coverage of this section of the Canyon.

The Grand Canyon Series

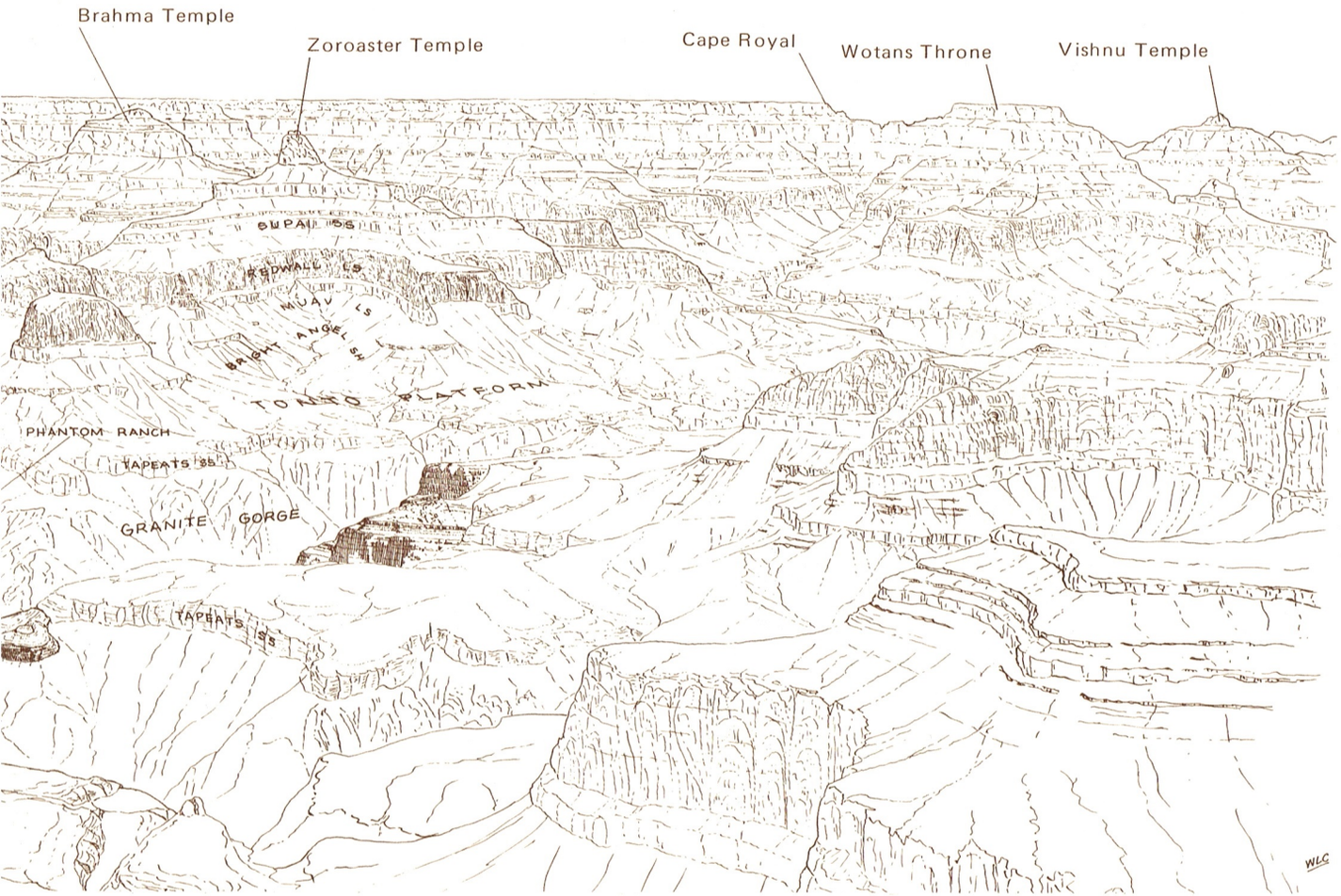
The wedge of the Grand Canyon Series below Cheops Pyramid, seen from all points on the South Rim from Yavapai to Pima, is best displayed in the foreground north of Maricopa Point. These rocks are exposed from Bright Angel Creek to the west end of the panorama; they are tilted to the east and are predominantly red in color. Because of their importance in both scenery and geologic history, they are highlighted on the sketch. This exposure of the Grand Canyon Series is some 4 miles long, and it serves to emphasize the three-fold division of the major rock bodies exposed in the Canyon. A segment of the Grand Canyon Series deformed by drag folding along the Bright Angel fault zone is visible just east of Plateau Point, on the east bank of Garden Creek south of the Colorado River.

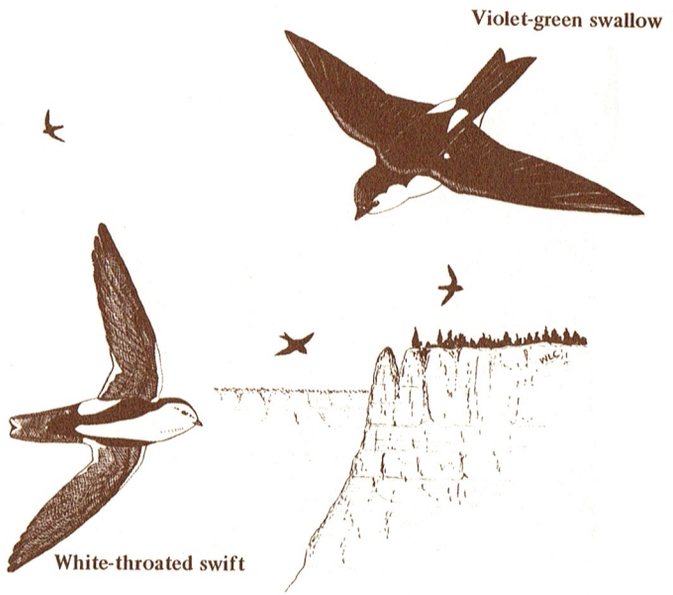
The Granite Gorge

Throughout the segment of the Canyon visible from Maricopa Point, the Colorado River flows through the deep Granite Gorge, capped by the cliff of Tapeats Sandstone. Here the bottom of the Granite Gorge is 1500 feet below the Tonto Platform, so the river itself is not visible from the viewpoint. Excellent views of pink vertical dikes can be seen in several parts of the Granite Gorge, especially near the west end.

Bright Angel Creek

The extension of Bright Angel Creek far into the North Rim is strikingly apparent from Maricopa Point. This canyon is eroded along the Bright Angel fault and extends northward in a nearly straight line for more than 11 miles.





Some birds commonly seen in flight at the rim points.

Movement along the fault occurred both before and after the Paleozoic rocks were deposited.

The Temples

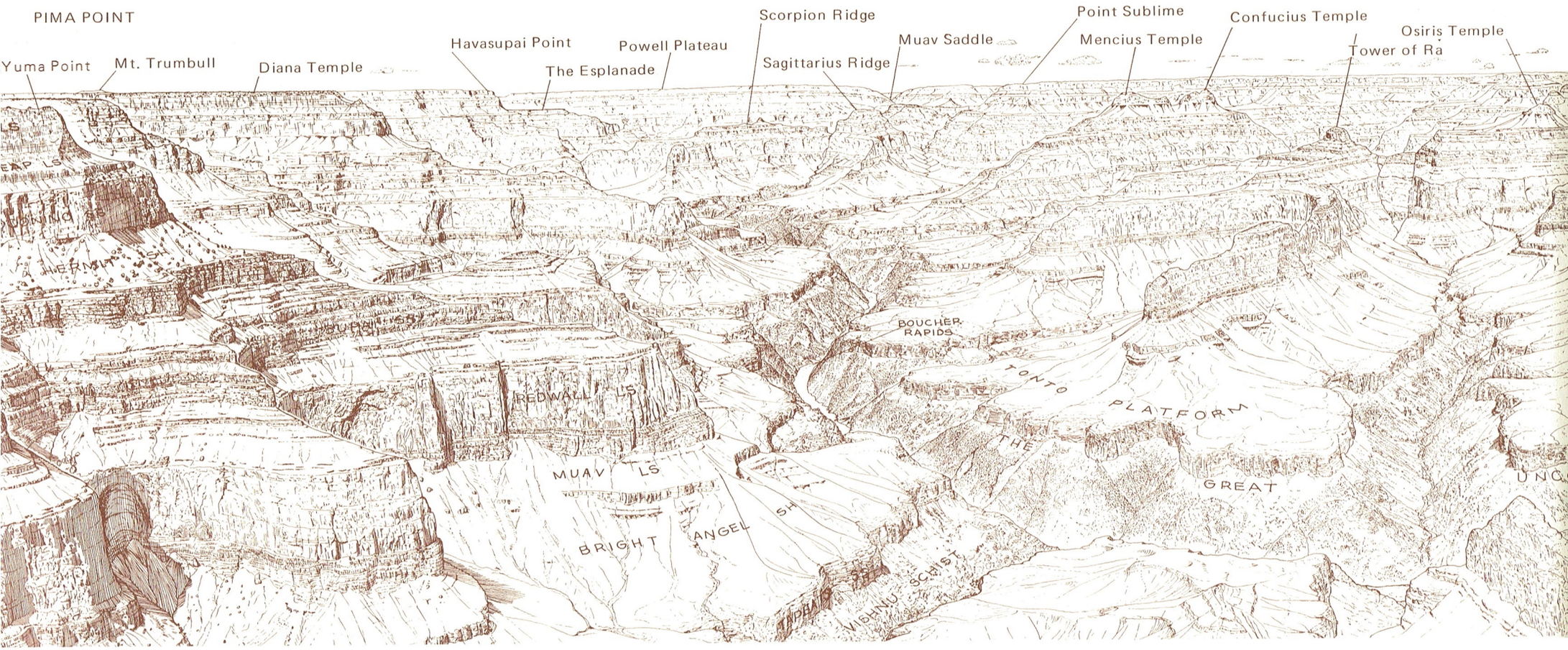
The view from Maricopa Point provides an excellent perspective of the many temples and buttes carved from the North Rim. Most of the temples, such as Isis, Buddha, Manu, Brahma, Deva, and Zoroaster are capped by the resistant Coconino Sandstone, and evolved by erosion and wasting of larger mesas which are usually cut off from the main North Rim by faults. Accelerated erosion along the fault zone resulted in eventual isolation of the mesa or butte. The abundance of temples on the North Rim produces much of the scenic beauty of the Canyon wall, as seen from the South.

Ecology

The West Rim Drive winds through the pinyon - juniper forest typical of this section of the Coconino Plateau. The dominant trees are the Pinyon Pine *(Pinus edulis)* and Utah Juniper *(Juniperus osteosperma).* Cliffrose is commonly associated with the trees, and the understory is characterized by *Yucca, Ephedra* ("Mormon tea"), big sagebrush, and other shrubs. All along the North Rim, across the Canyon, can be seen the denser Ponderosa Pine forests of the Kaibab Plateau, with fairly thick stands of pinyon-juniper extending well down into the Supai Formation.

Note that many of the trees along the West Rim Drive support rather extensive growths of mistletoe. The species occuring on the junipers is *Phoradendron juniperinum;* a second species, the dwarfmistletoe, occurs on pinyon. These are true parasites, in that they obtain all of their nutrients from the tissues of the host trees.

Thermal updrafts, a characteristic phenomenon at all of the rim points, provide an ideal medium for a variety of soaring and scaling birds. Frequently seen at the points are two species of summer nesting birds whose rapidly darting flight is an adaptation for preying upon aerial insects. These two, the White-throated Swift and the Violet-green Swallow, show some superficial resemblances but may be distinguished on the basis of color pattern and mode of wingbeats (see above). The thermal currents are also utilized to good advantage by the more strictly soaring species, such as the ravens, hawks, and falcons.



PIMA POINT

Location: 8 miles west of the Visitor Center on the West Rim Drive.

Elevation: 6798'

Of the accessible viewpoints along the West Rim Drive, the most frequently visited are probably Hermits Rest and Hopi Point. While these are justly famous for their scenic attractions, the most significant panorama in terms of natural processes, as well as scenic appeal, is that seen from Pima Point. The Point projects out into the Canyon as a spur between Hermit Creek and Monument Creek, and presents an unobstructed view of nearly 180 degrees. To the northwest can be seen Ives Point and Mauv Saddle on the Powell Plateau, some 26 miles away. To the east, Wotan's Throne and Cape Royal, 15 airline miles distant, are clearly in view.

Granite Gorge and Great Unconformity

In the foreground, 2 to 3 miles from the South Rim, the Colorado River flows in a broad arc and cuts deep into the Granite Gorge to expose an exceptionally large segment of the Precambrian metamorphic rocks. Pink granite dikes locally intrude the metamorphic complex and in places form an interlacing network (see fig. a, page 22, for telescopic detail). The Bright Angel Shale has been stripped away from the Tapeats to form the broad terrace known as the Tonto Platform. This terrace is more than a mile wide in many places, and is particularly well developed here.

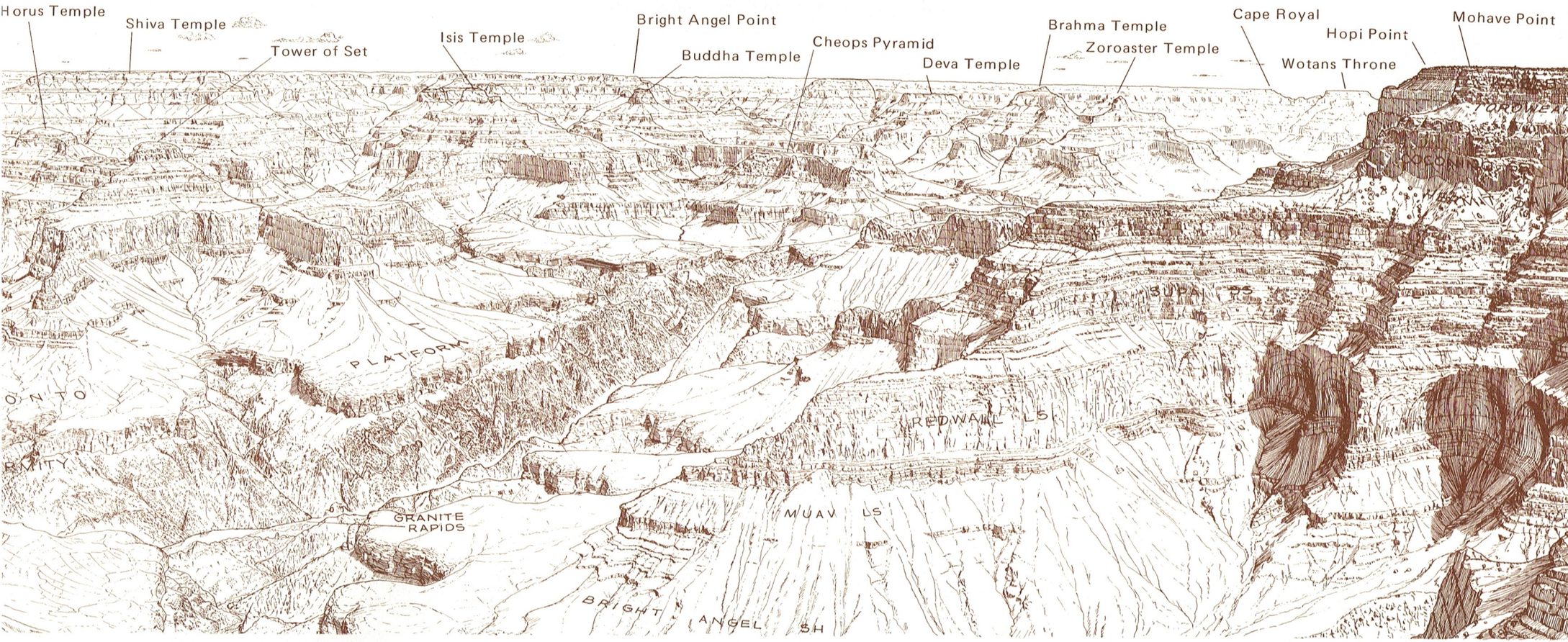
Pima Point is exceptional in providing an extensive continuous exposure of the Great Unconformity, marked by the Tapeats Sandstone atop the vertical Precambrian series. Exposures of the Granite Gorge are enlarged and enhanced by tributary streams such as Ninety-four Mile Creek, Hermit Creek, and Monument Creek, which have dissected the Tonto Platform and formed side canyons cut in the underlying metamorphic rock.

Canyon Profile

The view from Pima Point shows the striking asymmetry of the Canyon. The river is less than 2 miles from the South Rim, and reference to the steep profiles of the walls at the margins of the panorama will indicate that the South Rim has suffered relatively little erosion. The North Rim of the Canyon, in contrast, is 5 to 6 miles back from the river and the walls are highly dissected by long streams which flow southward into the river.

Above the Tonto Platform the scenery of the Canyon is dominated by three horizontal Paleozoic formations: the Redwall Limestone, the Supai Sandstone, and the white Coconino Sandstone. The vertical cliff of the Redwall Limestone typically erodes into large alcoves and amphitheaters which are exceptionally well expressed in the Pima Point area, particularly below the large temples on the North Rim.

The overlying Supai Sandstone is eroded into a series of alternating small cliffs and slopes. Because of its red color, it



is one of the more striking formations within the Canyon. North of the river, the red Supai and underlying Redwall formations dominate the center of the scene and form most of the temples and towers.

In the far background below the North Rim the white cliff of the Coconino Sandstone stands out in marked contrast to the red Supai Formation. The gray Kaibab and Toroweap limestones, largely covered with forest vegetation, form the Canyon rim.

The Muav Fault

From Pima Point the Coconino appears as a horizontal white band which extends across the entire panorama. If the visitor will trace the Coconino Formation westward past Point Sublime to the Muav Saddle, he will note a significant offset in the rock sequence produced by the Muav fault. The strata are down-dropped to the west, and the Coconino Sandstone is flexed into a large graceful arc, bending down into the fault plane (see fig. b, page 22, for telescopic detail).

Rapids

Two of the many rapids on the Colorado River are visible from Pima Point. Although Granite Rapids is 4400 feet below the rim and almost 3 miles to the north, the whitewater of the rapids is visible for nearly 3/4 of a mile (see fig. c, page 22, for telescopic detail). Part of Boucher Rapids in the western section of the panorama is also in view. The abnormally steep tributaries are able to transport large boulders and great quantities of debris down to the river at a rate far greater than the Colorado River is able to move them on downstream. Granite Rapids is formed by boulders brought down by Monument Creek. Large boulders and blocks up to 10 feet in diameter have accumulated at the mouth of Monument Creek and partly obstruct the channel of the river, causing a steep drop of some 17 feet.

Ecology

From Pima Point it is possible to trace the pinyon - juniper communities down the Canyon slopes several hundred feet, well into the Hermit - Supai formations. It is obvious, however, that the growth of the trees is much restricted in both size and density below the rim. The dominant plants in the lower parts of the Canyon are various species of desert shrubs, which give the surface of the Tonto Platform a greenish-gray stippled appearance. A view through binoculars will reveal that this shrubby vegetation is more abundant than might otherwise be supposed.

The intermittant streambeds of the nearby drainage systems (i.e., Hermit, Monument, and Ninety-four Mile creeks) are bordered by clusters of plants such as mesquite and catclaw acacia; these require the somewhat moister and better drained soils occurring in such situations.

Hermit Trail and Camp

Below Pima Point to the west can be traced the outline of Hermit Trail, and square outlines of the foundations of cabins at the old Hermit Camp can still be seen. The Hermit Trail was built in 1912 by the Santa Fe Railroad to provide access to the inner Canyon. Hermit Camp was used as an overnight guest ranch in the same manner as Phantom Ranch today. The trail and camp were abandoned in 1930.

TELESCOPIC DETAILS FROM PIMA POINT

Fig. a. Interlacing network of dikes injected into the metamorphic rocks of the Granite Gorge, as seen northwest from Pima Point.

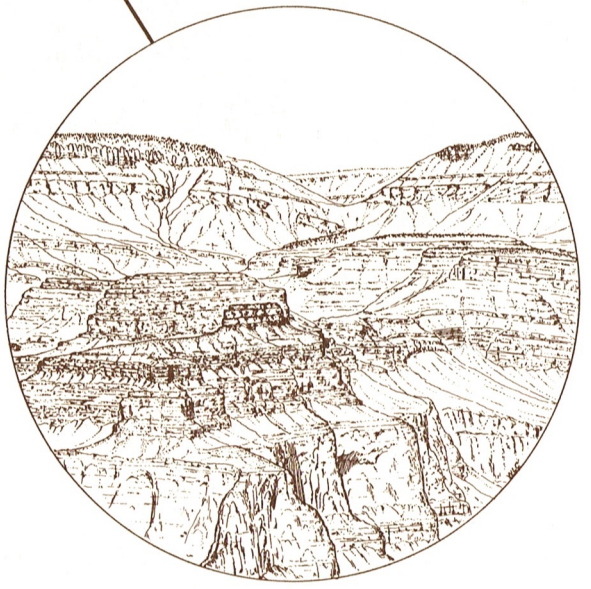


Fig. b. Muav Saddle as seen from Pima Point. Note displacement of the Coconino Sandstone resulting from movement along the Muav fault.

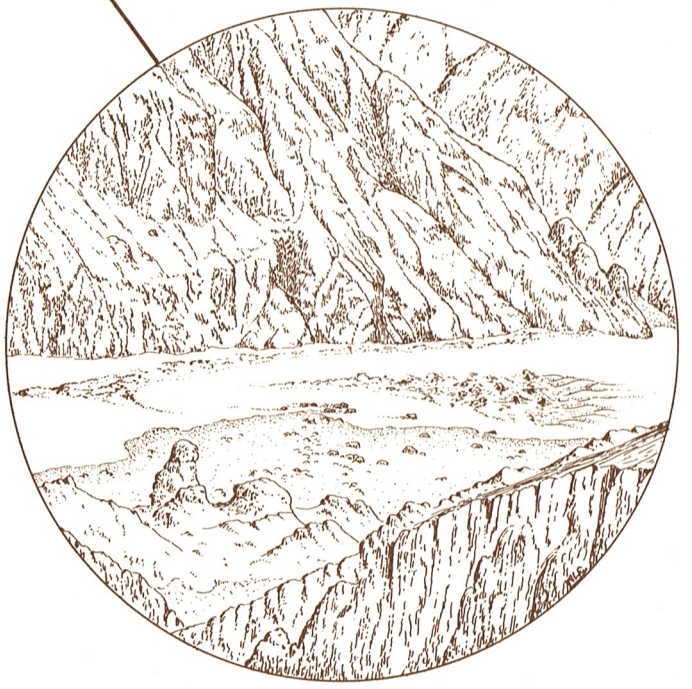


Fig. c. Granite Rapids, below Pima Point.

TELESCOPIC DETAILS FROM YAVAPAI POINT

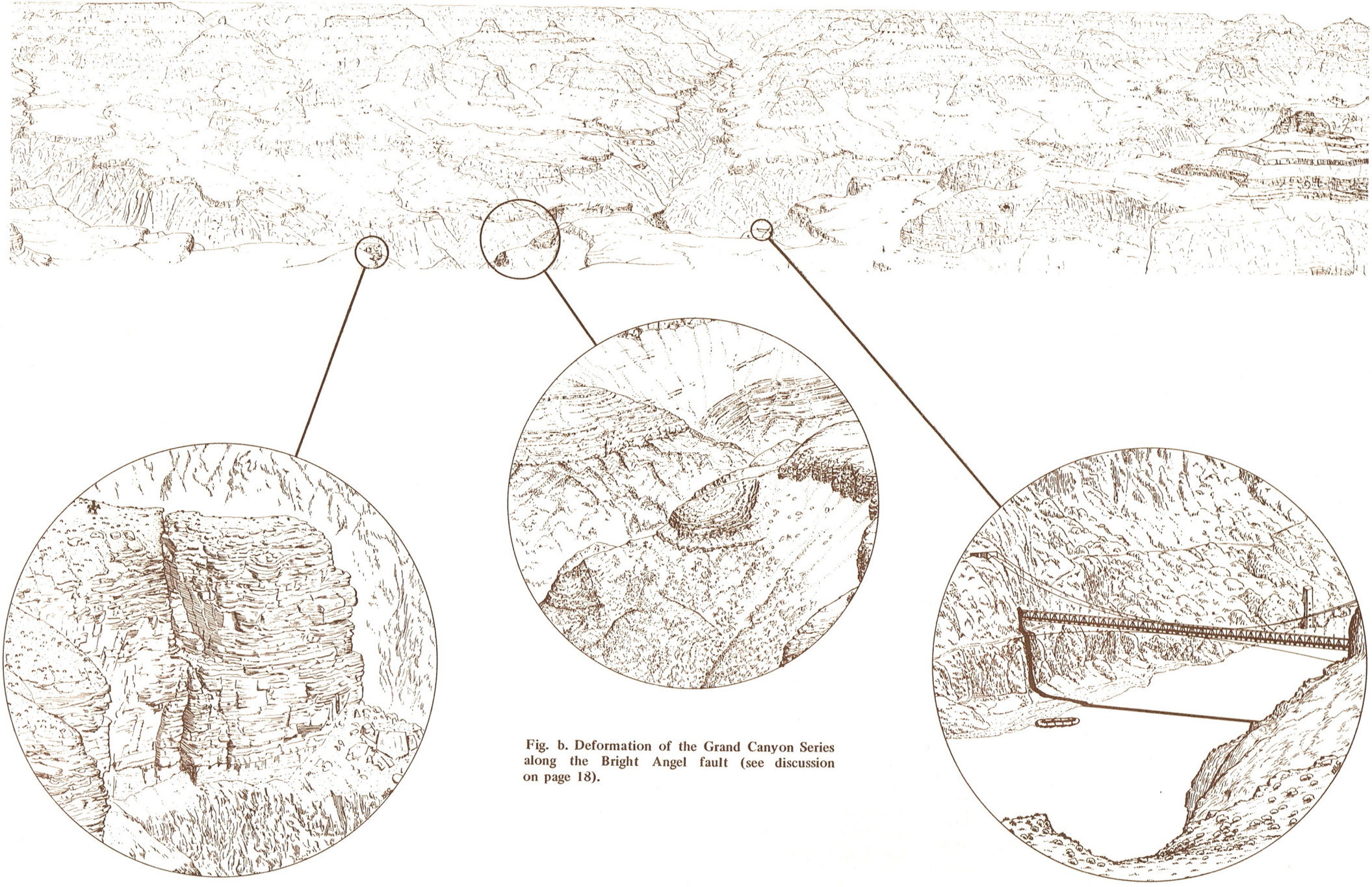
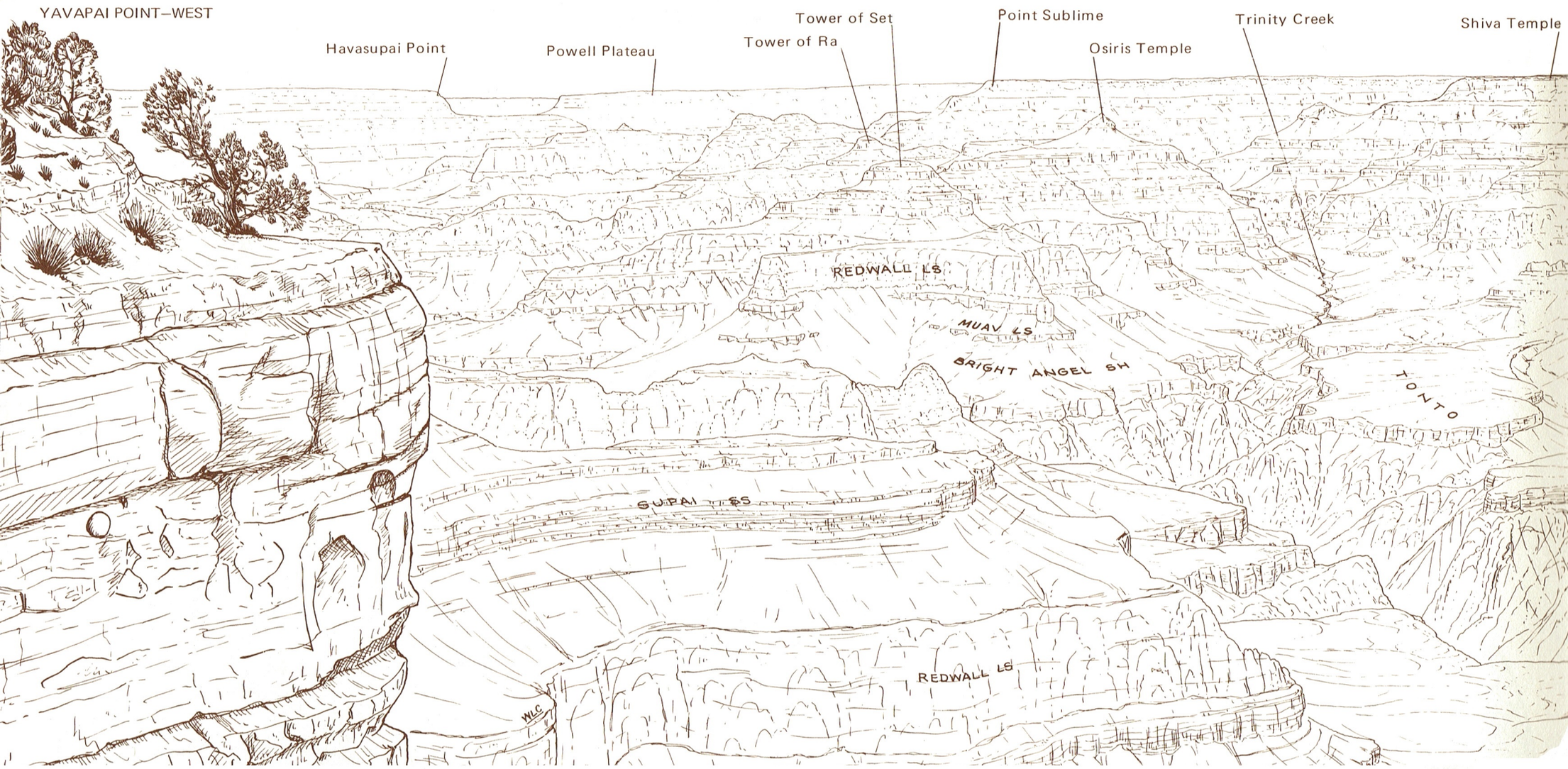


Fig. a. Plateau Point as seen from the rim at Yavapai. It is reached by trail from Indian Gardens, and provides an overlook of the Granite Gorge.

Fig. b. Deformation of the Grand Canyon Series along the Bright Angel fault (see discussion on page 18).

Fig. c. Kaibab Suspension Bridge near the mouth of Bright Angel Creek as seen from Yavapai Point. The bridge is 440 feet in length, and 60 feet above the river.



YAVAPAI POINT

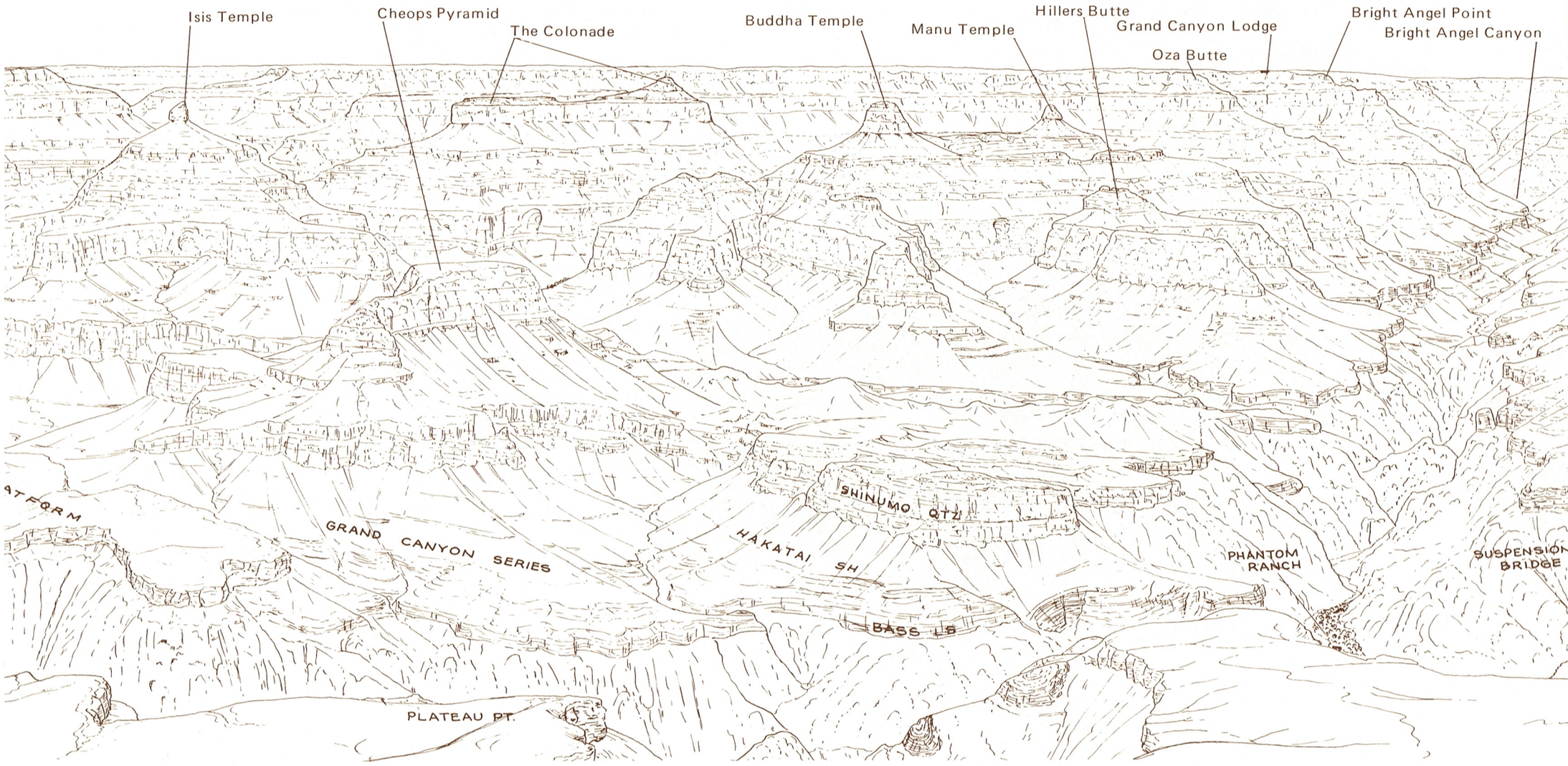
Location: One-half mile northeast of the Visitor Center. A short spur road leads from the main entrance road to the parking area and museum. It may also be reached by self guiding foot trail from the Visitor Center or village area. The views are similar from Mather and Yaki points, which are the next accessible points to the east.

Elevation: 7073'

Yavapai Point is located midway along the first bold promontory to the east of Grand Canyon Village. Its ease of accessibility, coupled with the presence here of a small museum and interpretive station, have made Yavapai one of the most visited of all the Canyon viewpoints. The panoramic view here is a full 180 degrees, and affords examination of most of the significant features that can be seen from the South Rim. For convenience of format the panorama is divided into east and west sections.

The Canyon Wall

The central location of Yavapai Point together with the broad panoramic view of the North Rim makes this an ideal place from which to see the typical features of the Canyon wall. Although the Colorado River can be seen in only a few isolated spots, the Granite Gorge in the lowest part of the Canyon extends across most of the panorama. The Tapeats Sandstone forms the lowest of a sequence of cliffs cut on the more resistant units of the horizontal Paleozoic rocks, and stands out in striking contrast to the ragged V-shaped Granite Gorge below and the broad Tonto Platform cut on the overlying greenish-gray Bright Angel Shale above. The central part of the Canyon wall is dominated by the red rocks of the Hermit, Supai, and Redwall formations. Perhaps the most imposing rock body is the Redwall Limestone, which forms the vertical cliff over 500 feet high. The character of the Redwall cliff changes only slightly from one end of the Canyon to the other; its trend is highly irregular,



being scalloped into large curving alcoves separated by long narrow spurs. Prominent caves and arches can be seen to the northwest behind Cheops Pyramid and in the foreground below O'Neill Butte.

The Muav Limestone, underlying the Redwall, is relatively inconspicuous and is generally not stained red. It is typically greenish-gray and is commonly covered with slope wash. For these reasons it is difficult to distinguish from the underlying Bright Angel Shale.

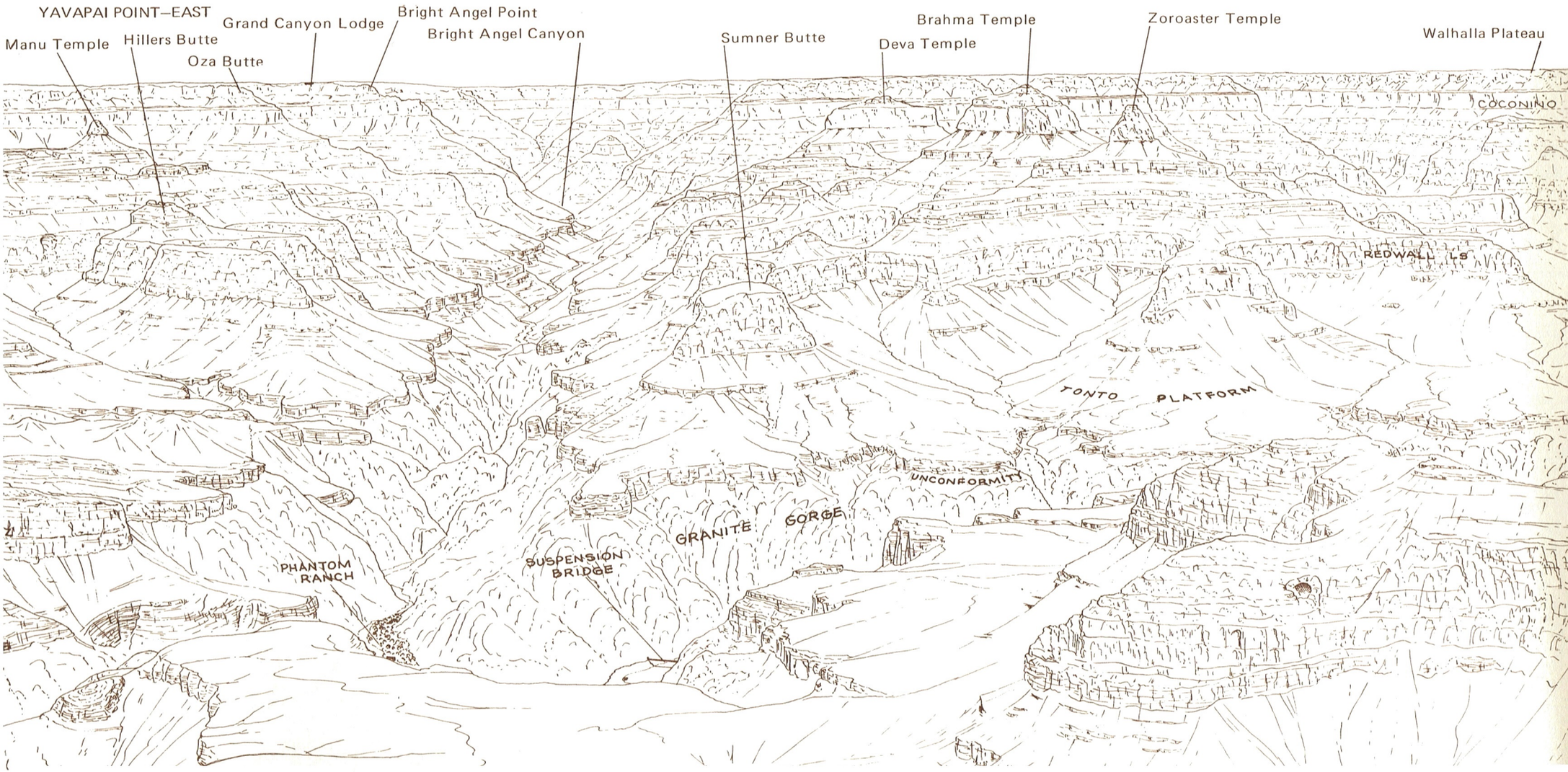
The Supai and Hermit formations are the red sandstones and shales in excess of 1,000 feet thick which overlie the Redwall and are located approximately midway between the Canyon rim and the Tonto Platform. The Supai responds to erosion by forming a series of alternating small cliffs and slopes.

The Temples

The scenic grandeur of the Canyon is greatly enhanced by the numerous "temples" carved on the North Rim. Technically these are simply buttes capped by a resistant rock unit and commonly eroded into a pyramid-shaped remnant. The Coconino Sandstone forms the cap rock for most of the higher temples, such as Zoroaster, Brahma, Isis, and Osiris. The older and lower buttes, such as Horus Temple, Tower of Set, and Cheops Pyramid, are located near the end of the spurs and are capped with either Supai or Redwall. The larger buttes, mesas, or spurs such as Shiva Temple, Wotan's Throne, and Vishnu Temple are still capped by the Kaibab Limestone.

The Grand Canyon Series

The wedge of the Grand Canyon Series below Cheops Pyramid seen from Pima Point, Maricopa Point, and El Tovar is visible from Yavapai Point with a perspective similar to that seen from El Tovar. The Grand Canyon Series is inclined to the east and is bounded above and below by two major unconformities. The rocks are mostly dark red and vermilion sandstones and shales. In addition to the inclined position of the wedge of the Grand Canyon Series, several isolated exposures show more intense folding which occurred before the overlying horizontal Paleozoic rocks were deposited. The most spectacular of these are near the Bright Angel fault on both the north and south side of the river, where there occurred local folding associated with movement along this fault prior to the deposition of the Paleozoic rocks.



Granite Gorge

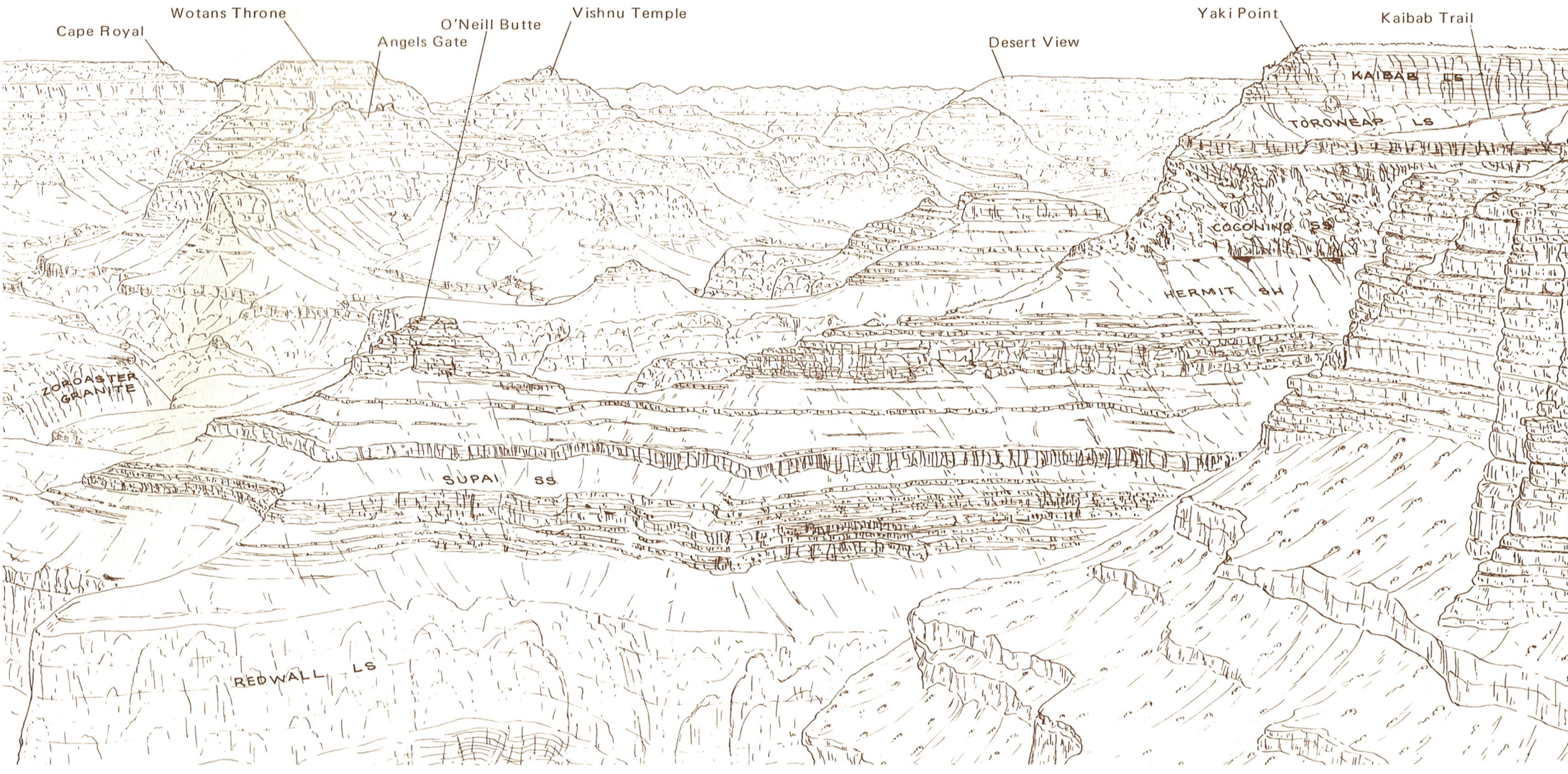
From Yavapai Point a large segment of Granite Gorge is visible, extending from Clear Creek below Wotan's Throne on the east, to Trinity Creek beneath Shiva Temple on the west. Within this area is one of the most variable segments of the Gorge. Near Clear Creek it exposes the Vishnu Schist, a metamorphosed sequence of sedimentary rock which is now fused into a hard resistant mass. It is distinguished by its dark black color. A short distance downstream from Clear Creek is the largest intrusive igneous body exposed in the Canyon. This rock is the pink colored Zoroaster Granite, the upper part of which is exposed to the left of O'Neill Butte. In the vicinity of Bright Angel Creek occurs the Brahma Schist, a greenish metamorphic rock laced with numerous pink granitic dikes.

To the west of Bright Angel Creek the Grand Canyon Series overlies the metamorphic rock, so that the typical expression of the upper part of the Gorge is modified by the presence of inclined orange and red sandstones and shales. Several large segments of the Grand Canyon Series are separated from the main mass below Cheops Pyramid and exist as isolated inclusions within the metamorphic rocks of the Granite Gorge.

The Trail System

The transcanyon trail system, major elements of which are seen from Yavapai Point, is the only practicable surface means of crossing the Colorado River and its canyons between Navajo Bridge and Hoover Dam, a distance in excess of 300 miles. The North Rim terminus of the Kaibab Trail begins near Grand Canyon Lodge on the opposite rim and descends into Bright Angel Canyon, which forms a natural avenue for the greater distance of the route. Several camp sites, the largest of which is at Phantom Ranch, are located in this tributary canyon.

Upstream on the Colorado River from the mouth of Bright Angel Creek, the trail crosses the river by means of the Kaibab Suspension Bridge (see fig. c, page 23, for telescopic detail). On the south side of the river the trail divides. The east route is the continuation of the Kaibab Trail proper which ascends the Canyon wall in rather direct fashion, climbing the long spur known as Cedar Ridge and topping out at Yaki Point to our immediate east. The other route, known first as the River Trail, swings west to where Garden Creek meets the river. From there it becomes the famous Bright Angel Trail, and ascends to Grand Canyon



Village via Indian Gardens and a series of seemingly endless switchbacks. The trail out to the end of Plateau Point is a scenic diversion from the main route; it provides an opportunity for a view of the Inner Gorge and the Colorado River for those not making the longer trip to Phantom Ranch (see fig. a, page 23, for telescopic detail).

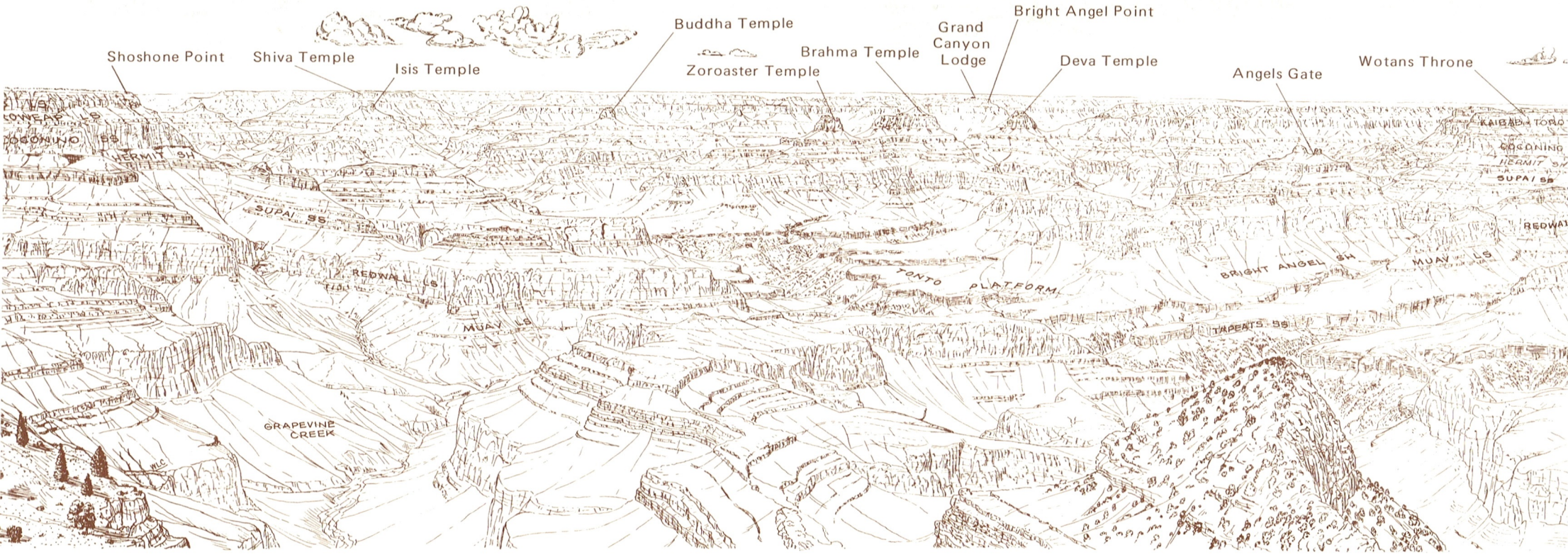
Ecology:

Some ten miles across the Canyon from Yavapai Point, on the east wall of Clear Creek Canyon, is located Cheyava Falls, one of the few large waterfalls within the Canyon proper. The water, which drops a distance of about 600 feet plus several hundred feet of cascades, issues from a cavern in the Redwall Limestone. No estimate of discharge is available, but maximum flow occurs in the spring months. The source of the water is undoubtedly in ground water supplies collected atop Walhalla Plateau and seeping down in a southerly direction to the head of the Clear Creek drainage basin. Similar falls occur in numerous other places in the Canyon region; many can be seen at river level on float trips. Wherever the falls occur, they modify the prevailing environmental surroundings and produce special communities dependent upon the additional moisture provided by mist from the falls.

Even where no visible waterfalls or springs are discernable, there may be sufficient surface seepage of moisture to permit the growth of small "oases" of cottonwoods and other deciduous trees and shrubs. A typical example of this is the small grove at the west base of Sturdevant Point. These areas provide appropriate nesting and feeding habitat for certain species of birds and mammals which might otherwise be absent from the inner canyon, and as such serve as "ecological islands" in the desert communities prevailing here.

Immediately surrounding the base of the Yavapai Museum, various stages of pioneer plant succession on rock can be detected. The usual sequence on bare rock involves crustose lichens as the first pioneers, followed by foliose lichens, mosses, and eventually seed plants. Typically, a variety of distinctive invertebrate animals accompany the various stages.

A number of birds utilize the seeds of the Pinyon Pines, and several species are often seen at Yavapai Point. The jay or crow family (Corvidae) is particularly well represented among these seed eaters; this includes the Clark Nutcracker, Steller's Jay, Scrub Jay, and Pinyon Jay. Another prominent corvid in the Canyon region is the Raven, commonly seen soaring "hawk-like" on thermal updrafts near the rim points.



GRANDVIEW

Location: Eleven miles east of Grand Canyon Village along the East Rim Drive.

Elevation: 7496'

The panorama from Grandview, regarded by many visitors as one of the finest in the Canyon, is strategically located so that the relations of the eastern and western parts of the Canyon are clearly seen. This part of the Canyon was the site of some of the earliest tourist and mining activity in the area. In 1895 a two-story log structure hotel was built at Grandview, and for some time this was the leading tourist facility at Grand Canyon. Copper veins were mined in the 1890's on Horseshoe Mesa below Grandview, but tourism eventually proved more profitable than mining.

The North Wall

The north wall of the Canyon is best seen during the morning light where the vista extends from Vishnu Temple westward to Shiva Temple. The numerous temples seen on the North Rim present a spectacular display of color and erosion (see fig. a, page 30, for telescopic detail). All major elements of the classic section of the Canyon seen from points further west are clearly expressed. These include features such as the Tonto Platform, the Redwall cliff, and numerous small mesas or temples, many of which are capped by the Coconino Sandstone.

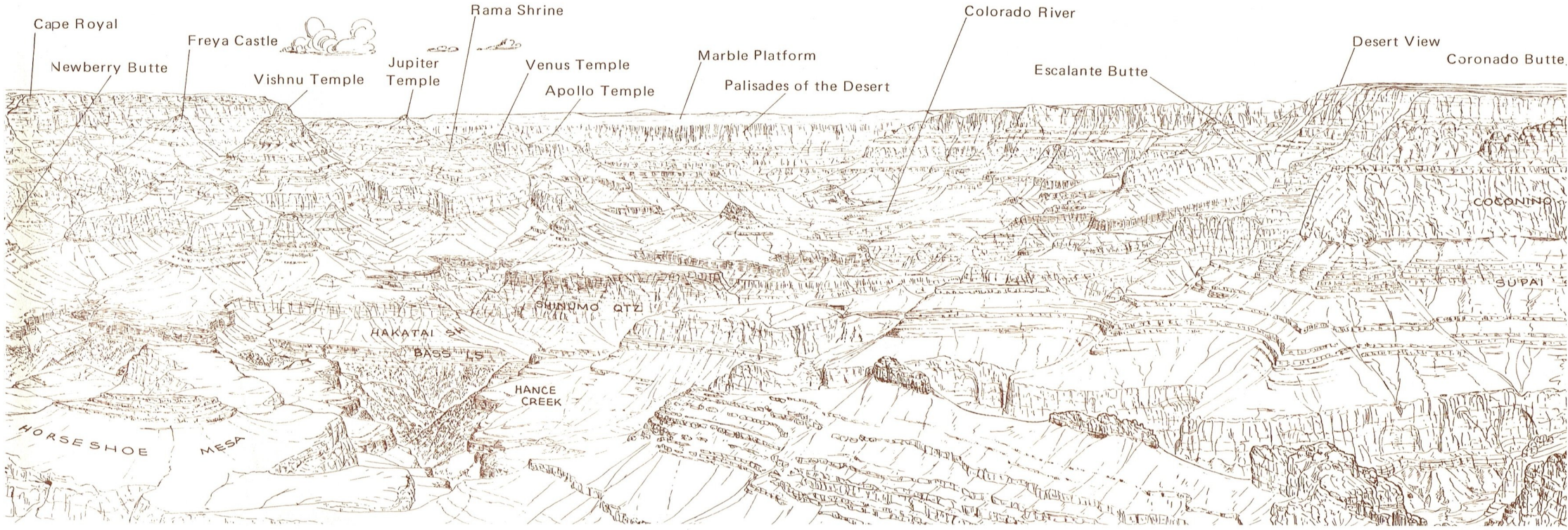
Granite Gorge

Although the Colorado River is visible only to the east, the upper part of the Granite Gorge is well exposed for some distance to the north and west. Throughout this extent only a few of the many features in the early Precambrian rocks can be seen, but the Great Unconformity at the base of the overlying Tapeats Sandstone is exceptionally clear. The Tapeats typically forms the lowest vertical cliff of the horizontal Paleozoic rocks and underlies the Tonto Platform above the Granite Gorge.

The Tonto Platform is best developed in the western part of the area, where in many places it is over a mile wide on either side of the river. The Platform is also present in most exposures to the east, but is not as impressive.

Grand Canyon Series

The profile of the lower part of the Canyon to the east of Grandview is controlled by the gently inclined strata of the Grand Canyon Series, and contrasts markedly with the Granite Gorge seen to the west. The great thickness of relatively soft shale and siltstone erodes to form a broader open valley at the bottom of the Canyon in the eastern section of the panorama, where the meandering Colorado is clearly visible.



The unconformity at the base of the Grand Canyon Series is well exposed through the valley east of Horseshoe Mesa almost due north of Grandview Point. The Bass Limestone and brick red Hakatai Shale dip to the east at an angle of approximately 10 degrees, whereas the foliation in the underlying metamorphic rock is nearly vertical (see fig. b, page 30, for telescopic detail).

Marble Platform

The flat surface of the Marble Platform can be seen to the east up the Canyon with the Echo Cliffs in the far background; it is a stripped surface on top of the Kaibab Limestone. The Marble Platform is 6000 feet above sea level, or 1400 feet lower than Grandview Point. The difference in elevation is largely the result of the East Kaibab monocline flexure which has elevated the plateau west of the Palisades of the Desert. This has permitted the deep canyon to be cut in this area. If it were not for the East Kaibab monocline, the walls of the Grand Canyon would probably be similar to those of Marble Canyon, and the lower Paleozoic rocks, Grand Canyon Series, and the Granite Gorge would not be exposed.

Grandview Monocline

The Grandview monocline, a flexure similar to the East Kaibab monocline but much smaller, is present on the South Rim to the east. The Grandview anticline is well expressed in the Redwall and Supai formations to the west where the strata rise in a flexure approximately 500 feet at Shoshone Point.

Ecology

At Grandview Point and its surroundings there are excellent examples of the typical South Rim vegetational complex, with well-developed Ponderosa Pine forests back from the rim, and pinyon-juniper stands out on the warmer and drier exposures provided by the points. Prominent shrubs include scrub oak, mountain mahogany, big sagebrush, and Mormon tea. A noteworthy feature of the Ponderosa forest in this particular area is the conspicuous understory of scrub oak, which reaches tree-like proportions beneath the large pines.

Between Grandview and Desert View along the East Rim Drive, the forests become almost exclusively pinyon-juniper. Elsewhere on the South Rim nearly pure stands of Ponderosa occur, and in other localities the two forest types intergrade. One reason for this is that at these elevations (ca. 7000 feet) the Ponderosa Pines are at the lower limit of their occurrence, while the pinyon-juniper forests are at the upper end of their altitudinal range. Recent studies have shed some light on the probable reasons for these patterns of distribution. Evidently these tree species react differently to soil moisture stress as seedlings. Ponderosa Pine seedlings generally require deeper soil or local microclimate conditions which allow them to make better use of what soil moisture is present. Minor fluctuations in precipitation during the past few hundred years seem to have favored establishment of Ponderosa seedlings during moister periods and pinyon-juniper seedlings during drier cycles. The forest stands which we see today are, therefore, an indication of climatic conditions which prevailed when these trees were seedlings, and are not necessarily indicators of present conditions.

TELESCOPIC DETAILS FROM GRANDVIEW POINT

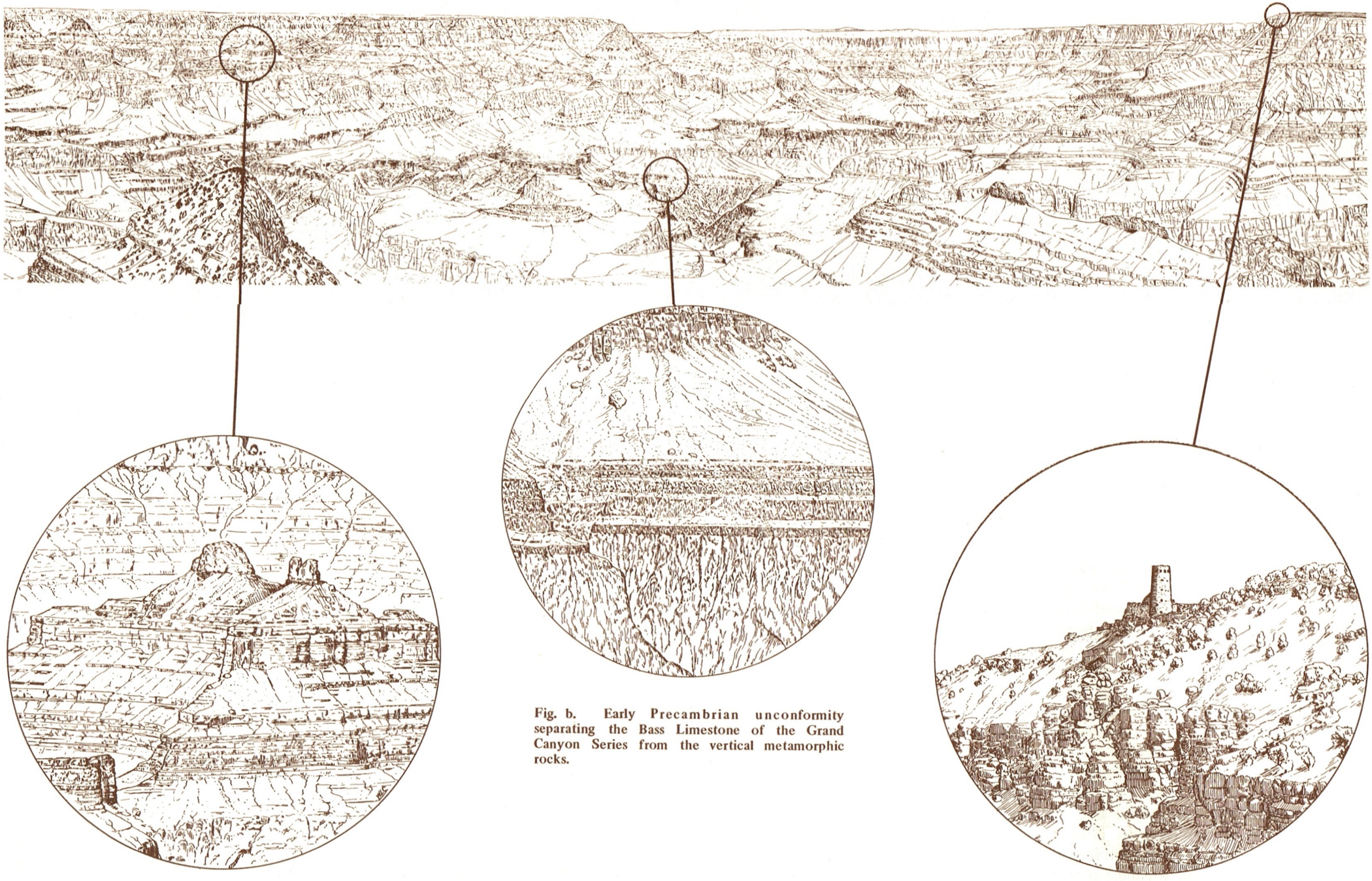


Fig. a. Angels Gate as seen from Grandview Point. This butte is typical of many erosional forms in the Canyon.

Fig. b. Early Precambrian unconformity separating the Bass Limestone of the Grand Canyon Series from the vertical metamorphic rocks.

Fig. c. Watchtower at Desert View as seen from Grandview Point.

TELESCOPIC DETAILS FROM LIPAN POINT

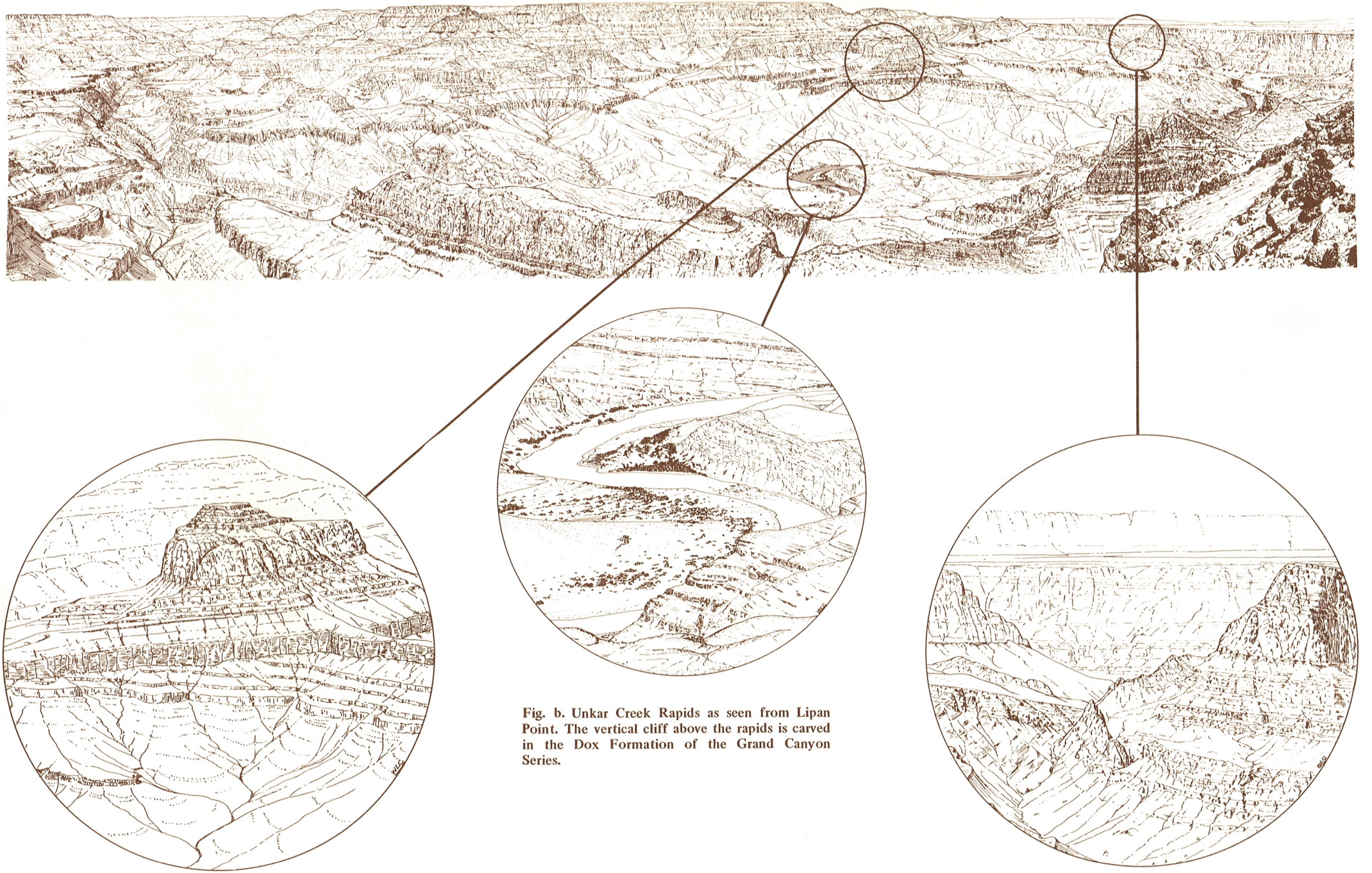
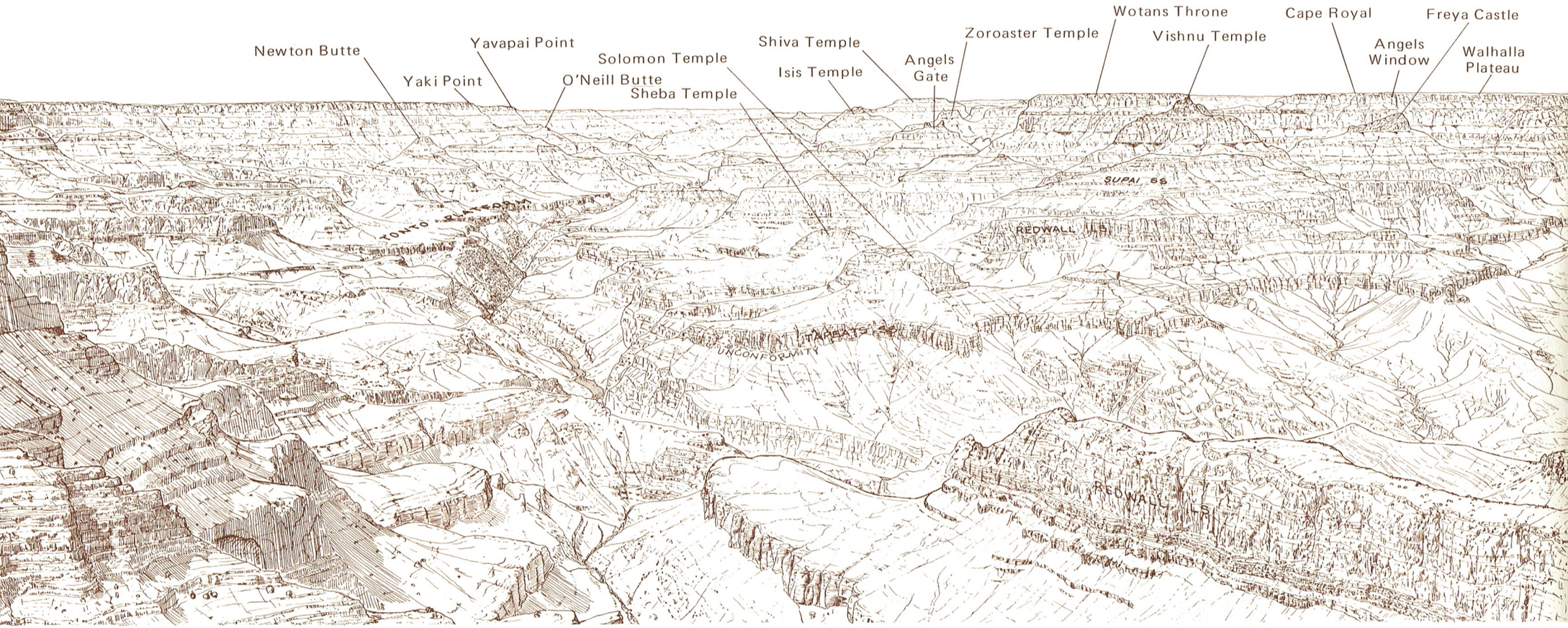


Fig. a. The Great Unconformity at the base of Apollo Temple, seen from Lipan Point.

Fig. b. Unkar Creek Rapids as seen from Lipan Point. The vertical cliff above the rapids is carved in the Dox Formation of the Grand Canyon Series.

Fig. c. Deformed Redwall and Supai formations along the East Kaibab fault at the base of Chuar Butte. The Palisades of the Desert are the nearly vertical cliffs in the background.



LIPAN POINT

Location: Twenty-two miles east of the Visitor Center and 3 miles west of Desert View on the East Rim Drive.

Elevation: 7300'

The eastern end of the South Rim of the Grand Canyon is located near the axis of the East Kaibab monoclinal uplift and provides a series of view points from which the visitor can see several unique features of the Canyon not exposed to the west. Paramount among these are (1) expression of the East Kaibab Monocline, (2) Marble Platform, (3) broad expanse of the tilted Grand Canyon Series of rocks located at the bottom of the Canyon, and (4) a view to the west through the center of the Canyon. Desert View (Navajo Point) is the most visited viewpoint in this area, owing perhaps to the presence of the watchtower and other tourist facilities. In our estimation, however, Lipan Point provides the more significant panorama of this segment of the Canyon, although the scene from both viewpoints is very similar.

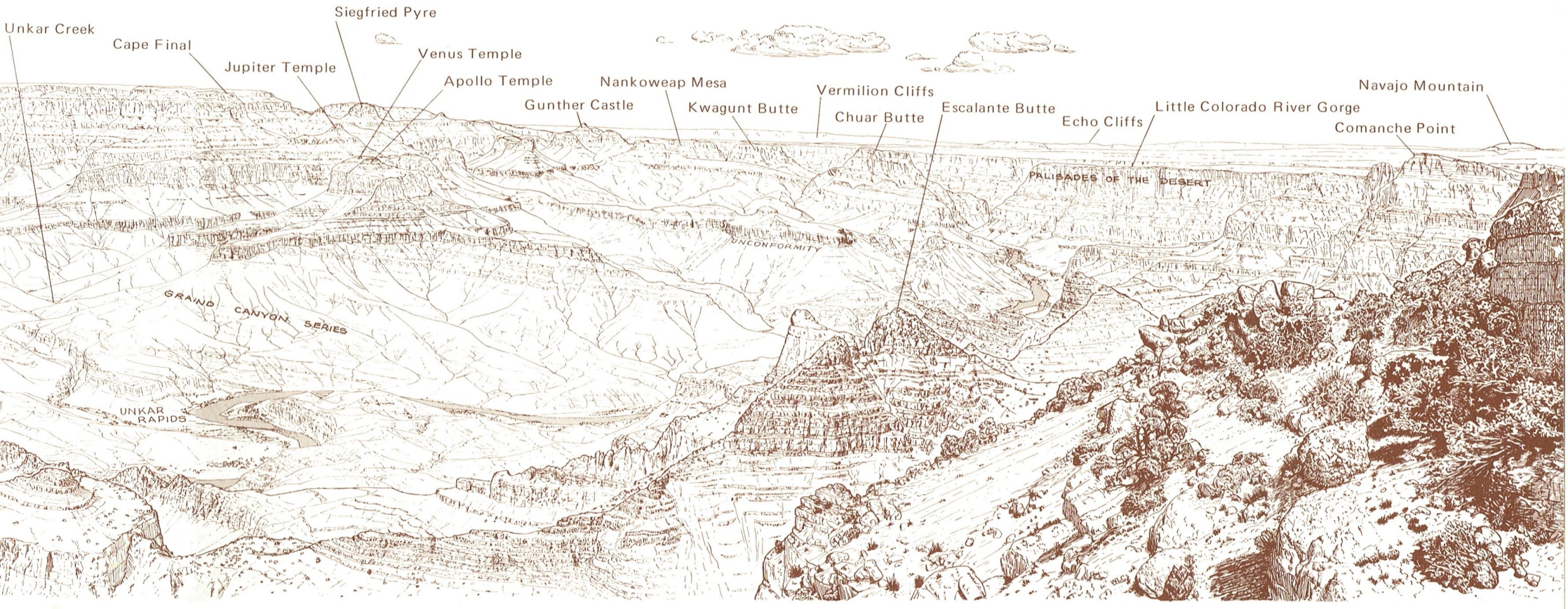
Marble Platform

The broad flat surface of the Marble Platform can be seen to the northeast of Lipan Point. On the distant skyline are the Vermilion cliffs to the north and the Echo Cliffs to the northeast. The rim of the Canyon below Marble Platform is very steep, and the typical step-cliff topography on the upper Paleozoic rocks is not well developed. Instead, the formations from the Kaibab to the Hermit form a nearly vertical wall known as the Palisades of the Desert (see fig. c, page 31, for telescopic detail). The asymmetry of the Canyon is clearly expressed in this part of the view; the Colorado River can be seen flowing less than a mile below the rim of the Marble Platform, whereas it is nearly eight miles from the North Rim.

The flexure of the East Kaibab monocline is not clearly expressed, but is indicated in this part of the Canyon by the difference in elevation between the North Rim (7916') and the Marble Platform (6000').

Grand Canyon Series

One of the most striking and significant features seen from Lipan Point is the broad surface of the Canyon bottom carved on the tilted strata of the Grand Canyon Series. These strata are dominantly red in the vicinity of Unkar Creek, but interbedded white units produce a distinctive striped appearance in the upper part of the sequence. Black volcanic rock injected into the series produces dark tones over much of the lower Canyon to the east. To gain a better appreciation of the thickness of this sequence of rocks the visitor should look downstream to the west, near the small stretch of river exposed south of Sheba Temple. The base of the Grand Canyon Series is marked here by a thin inclined white bed just above the river. Now look upstream to the stretch of the river below the Palisades; this is the upper part



of the sequence exposed here. It is apparent from these exposures that the Grand Canyon Series is much thicker than the overlying Paleozoic sequence. Lipan Point provides by far the most extensive view of this group of rocks.

The Great Unconformity is also well expressed across the river from Lipan Point, as the base of the Tapeats Sandstone can be traced across the tilted and beveled edges of the Grand Canyon Series for a distance of more than 20 miles (see fig. a page 31, for telescopic detail). Tapeats Sandstone rests directly upon the vertical metamorphic rocks which form the rugged Granite Gorge.

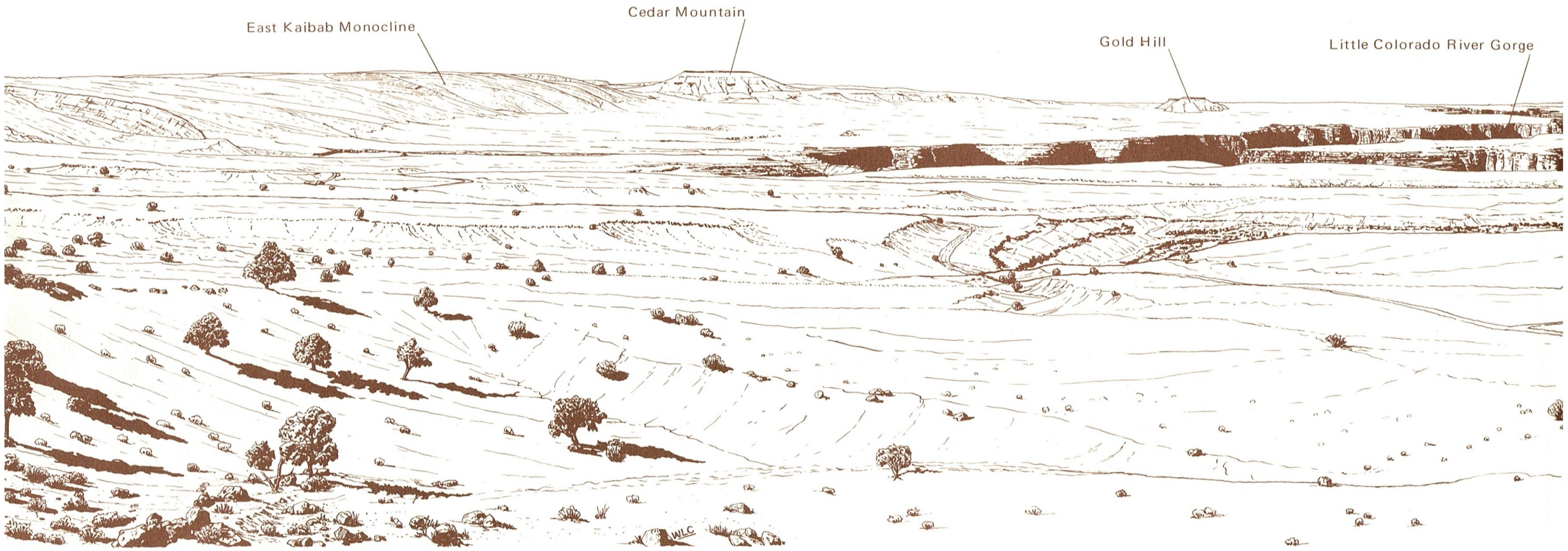
The Canyon Profile

The view to the west clearly reveals the wide terrace of the Tonto Platform carved atop the Tapeats, and the stair-like topography of the overlying Paleozoic strata. Also visible are some of the more prominent landmarks eroded from these Paleozoic rocks on the North Rim. If one looks carefully at the west flanks of Chuar Butte, to the northeast, it can be seen that the basal parts of the Paleozoic strata are upturned. This is due to movement along the East Kaibab fault, which trends in a north-south direction near the west margin of the butte. Here the Tapeats on the west side of the fault is adjacent to the lower Supai on the east side of the fault (see fig. c, page 31, for telescopic detail).

Unkar Rapids are visible at the mouth of Unkar Creek. An exceptionally broad fan of buff-colored debris, deposited like a delta, has in effect forced the river to migrate in a large meander bend and in the process cut a steep cliff in the red Dox formation (see fig. b, page 31, for telescopic details). The rapids result from large boulders brought down by floods on Unkar Creek which are too big to be removed by the Colorado River.

Ecology

Lipan provides an excellent view of large segments of the Colorado River. From this distance the streamside vegetation appears insignificant, but at river level it forms a fairly tall stand (10-20 feet in height) of willows, tamarix, mesquite, and certain other shrubs. This provides appropriate habitat for beavers, which are still found in some numbers along the River. The original fish fauna of the Colorado comprised a group of species adapted to survive in fast, turbid waters, and modified to subsist as either bottom feeders on organic debris or predators on small fish. Among the interesting species unique to the River are the Colorado River Squawfish, the Boneytail Chub, and the Humpback Sucker. Trout and other game fish have been introduced into some of the tributary streams. The recent construction of dams and impoundments along the Colorado has had profound effects on the ecology of the River; the once turbid waters are now generally clear for some miles below Glen Canyon Dam, except during periods of heavy runoff when much silt is brought into the river. While this may be favorable for some of the introduced species, the changed conditions are actually detrimental to the native fishes, which were well adapted for the murky, turbulent waters.



PAINTED DESERT OVERLOOK

Location: Thirty-nine miles east of Grand Canyon Village or 15 miles west of Cameron, Arizona.

Elevation: 5659'

The Marble Platform

The Marble Platform is a broad, stripped surface on top of the resistant Kaibab Limestone, and because of its low elevation (5500 to 4700 feet), it is sparsely vegetated. A few erosional remnants of the reddish-brown Moenkopi Formation, such as Cedar Mesa and Gold Hill, can be seen to the west rising 600 feet above the platform surface.

The East Kaibab Monocline

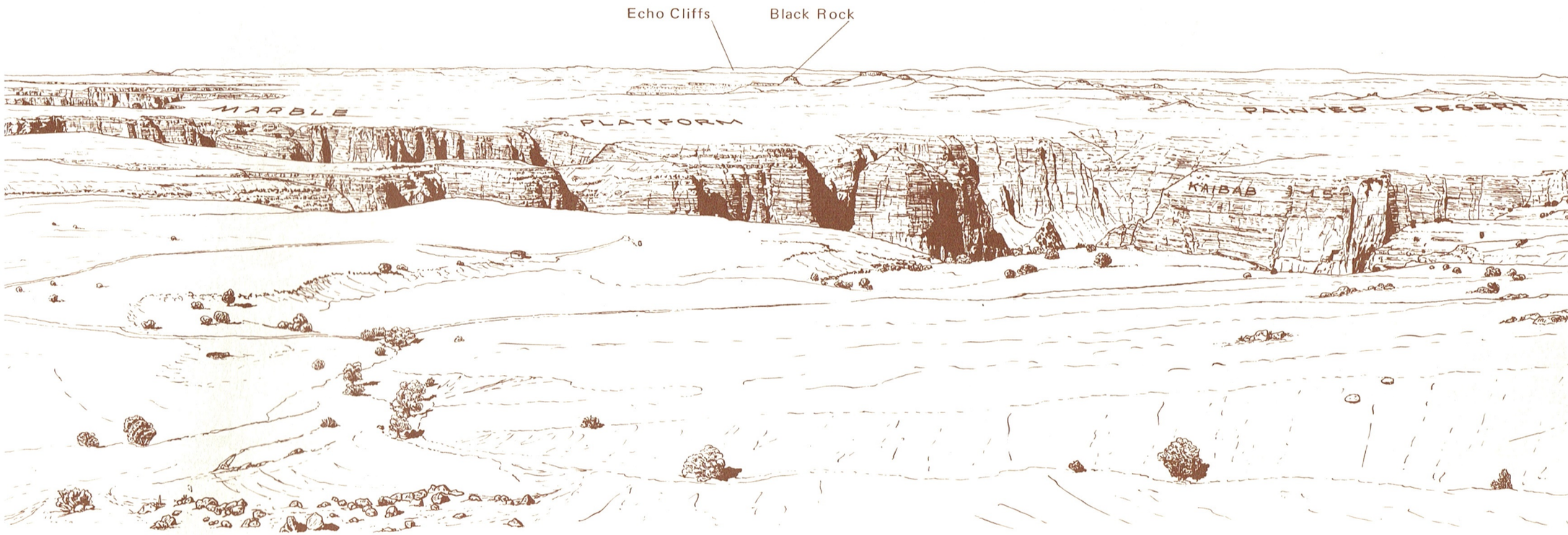
The East Kaibab monocline, one of the more important structural features in the Grand Canyon, is exceptionally well expressed to the west, where the nearly horizontal strata of the Marble Platform are flexed up into a broad fold. In road cuts to the west, steeply dipping strata of the Moenkopi and underlying Kaibab formations can be seen resulting from this flexure. West of this view point the Kaibab Limestone is more than 1000 feet higher than on the Marble Platform. This uplift played an important part in the development of the Grand Canyon inasmuch as the uplift of the land mass was necessary for the Colorado River to cut a deep canyon. In an area such as the Marble Platform where regional uplift is relatively small, the depth of the canyon is correspondingly less. West of the monocline the surface of the Kaibab Limestone ranges between 7000 and. 9000 feet, and in this vicinity the Canyon is over 5000 feet deep. East of the monocline the upper surface of the Kaibab is only 5000 feet high, and the canyons cut through this area range up to a maximum of 3000 feet in depth.

The Little Colorado River Gorge

The gorge of the Little Colorado River seen from this viewpoint ranges from 1600 feet to 2400 feet in depth. Within the gorge the strata of the Kaibab Limestone are etched out in remarkable detail revealing the intricacies of the internal structure of this formation. In the early stages of its development the Grand Canyon undoubtedly closely resembled the panorama seen from this viewpoint, and consisted only of a steep narrow gorge cut through the Kaibab Limestone.

Painted Desert

The famous Painted Desert of Arizona is a colorful badland topography carved mostly on the Chinle formation which is exposed in a zone extending from the base of the Echo Cliffs north of the Little Colorado River Gorge eastward to Holbrook, Arizona. Here in this vicinity the Moenkopi and younger Chinle formations are largely stripped

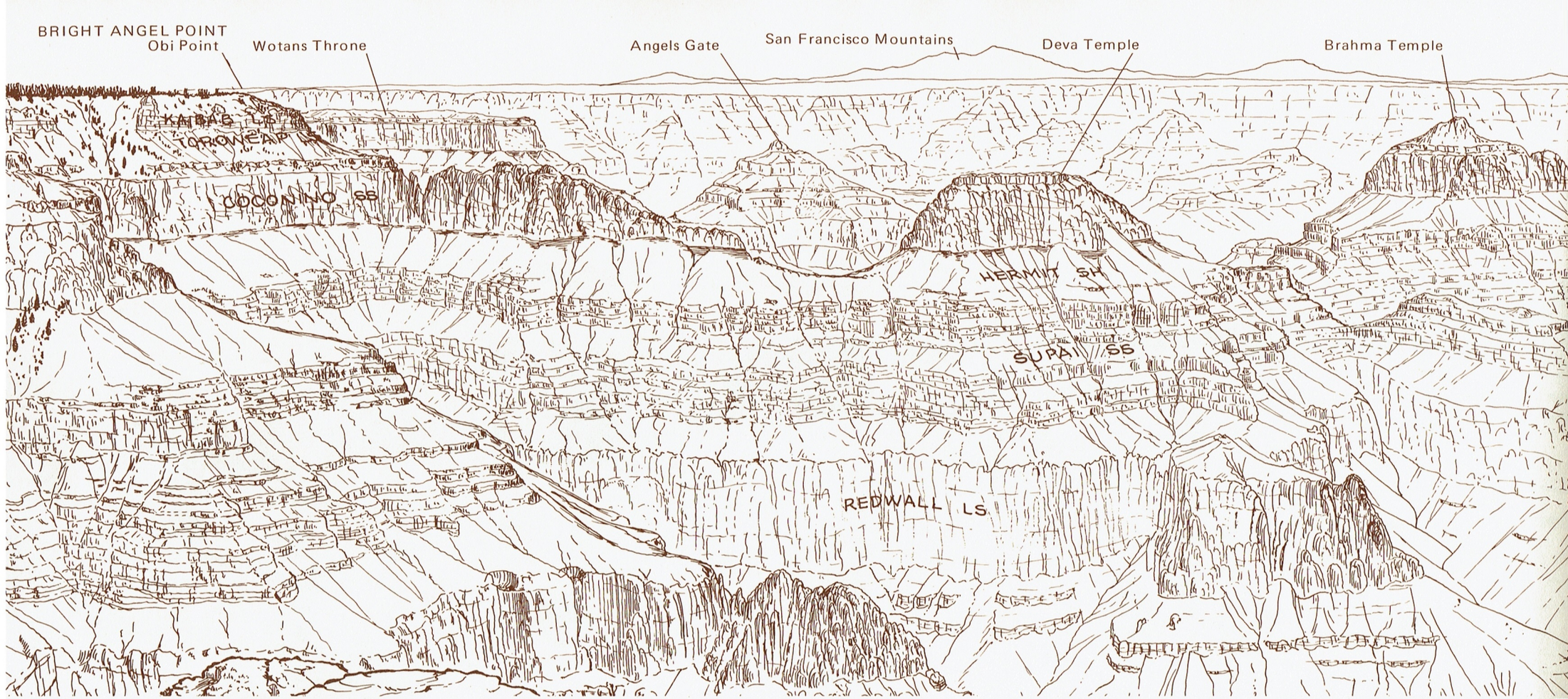


away from the resistant Kaibab Limestone, but the multicolored shales are well exposed to the east near Cameron. The view from here is near the northwest margin of the typical Painted Desert.

Ecology

Since the Painted Desert overlook is at the lowest elevation of any of the panoramas (5500 feet) we encounter ecological conditions considerably different than those prevailing in the National Park. This is a portion of the Navajo Indian Reservation, and as such has been subject to a greater variety of uses than areas within the Park. Grazing has undoubtedly had the greatest impact on the natural vegetation; the pastoral economy of the Navajos is still apparent in the herds of goats and sheep often seen in this area. Plants typical of the high desert communities dominate the foreground, with blackbrush the most conspicuous of the desert shrubs. An understory of herbs and bunchgrasses would normally be present, but these have largely been removed by livestock. Junipers, and perhaps a few pinyons, are scattered through the area. Actually this is at the lower end of the optimum altitudinal range for the pinyon-juniper woodland, which achieves its typical expression a few miles farther along towards the Park entrance. One of the few deciduous trees of the high desert, the single-leaf ash *(Fraxinus anomalous)* is also present here, showing a preference for the better-drained soils along the streambeds and washes. The typical high desert fauna includes the following mammals: rabbits, ground squirrels, kangaroo rats, wood rats, several species of mice, bobcat, coyote, gray fox, kit fox, and badger. Birds and reptiles, mainly lizards, are also well adapted for desert existence. The mammals tend to be mostly nocturnal, while the birds and many of the reptiles are diurnal in their activity.

Ord Kangaroo Rat,
***Dipodomys ordi,* a common nocturnal mammal of sandy desert areas.**



BRIGHT ANGEL POINT

Location: Bright Angel Point is the center of visitor activity on the North Rim, with a Ranger Station, campground, store, and lodge. The viewpoint is reached by a ¼ mile trail which begins at the parking lot just north of Grand Canyon Lodge. Informative self-guiding leaflets are available at the start of the trail.

Elevation: 8145'

Reference to the map (page 2) will reveal that Bright Angel Point forms a long spur projecting out into Bright Angel Canyon and dividing two of its major tributaries, Roaring Springs Canyon and The Transept. For this reason, the view is not dominantly one of the Grand Canyon proper, but rather a perspective of one of its major tributaries.

The Temples

The foreground is dominated by Deva, Brahma, and Zoroaster temples, a series of buttes on the east side of Bright Angel Canyon. The white Coconino Sandstone forms the bulk of the resistant caprock, although small vestiges of Toroweap or Kaibab limestones remain above the Coconino. Reference to the geologic map (page 2) will show a fault system which has helped control the erosion isolating these buttes from the main plateau on the North Rim.

Bright Angel Canyon

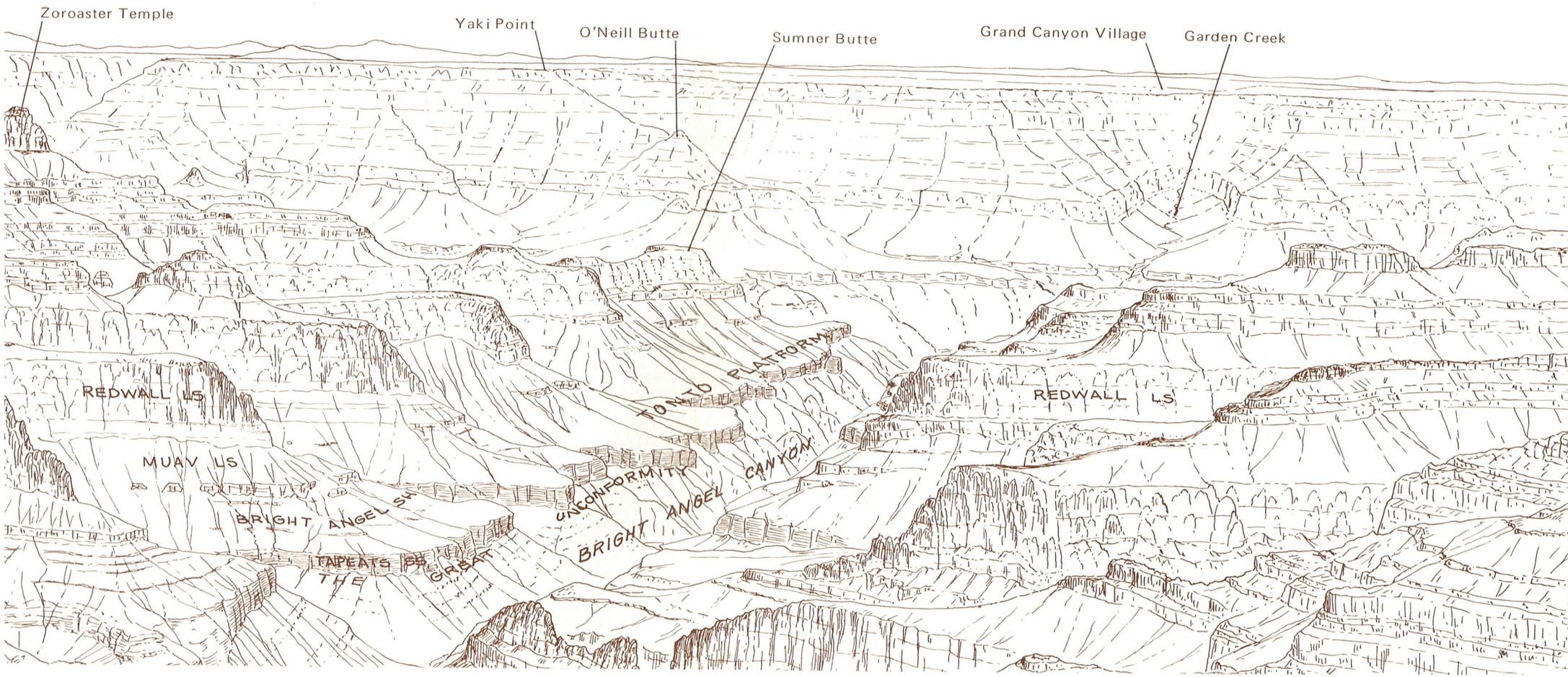
Erosion along the Bright Angel fault has produced this abnormally long, straight tributary canyon which extends northward from the river approximately 12 miles. Throughout half of this distance Bright Angel Creek has cut down below the Tapeats Sandstone and into the underlying metamorphic rocks to form a tributary to the Granite Gorge. In the upper part of Bright Angel Canyon is a small northeast dipping wedge of the Grand Canyon Series including the Bass, Hakatai, Shinumo, and Dox formations.

Near the headwaters of Bright Angel Canyon are numerous fresh scars of recent mud flows which have removed the soil and vegetation cover along the bottoms of steep tributary gullies.

The South Wall

In contrast to the rugged deeply eroded North Rim with numerous temples, mesas, and amphitheaters, the south wall of the Canyon is relatively undissected, and appears as a nearly vertical wall. The color of the Canyon is generally subdued by back lighting so that color contrasts between the gray, white, and red rock units are not always well defined.

In the background a small mesa formed by a lava cap on the Moenkopi Shale can be seen resting on the Coconino Plateau. The high volcanic peaks of the San Francisco Mountains are visible in the far distance.



Ecology

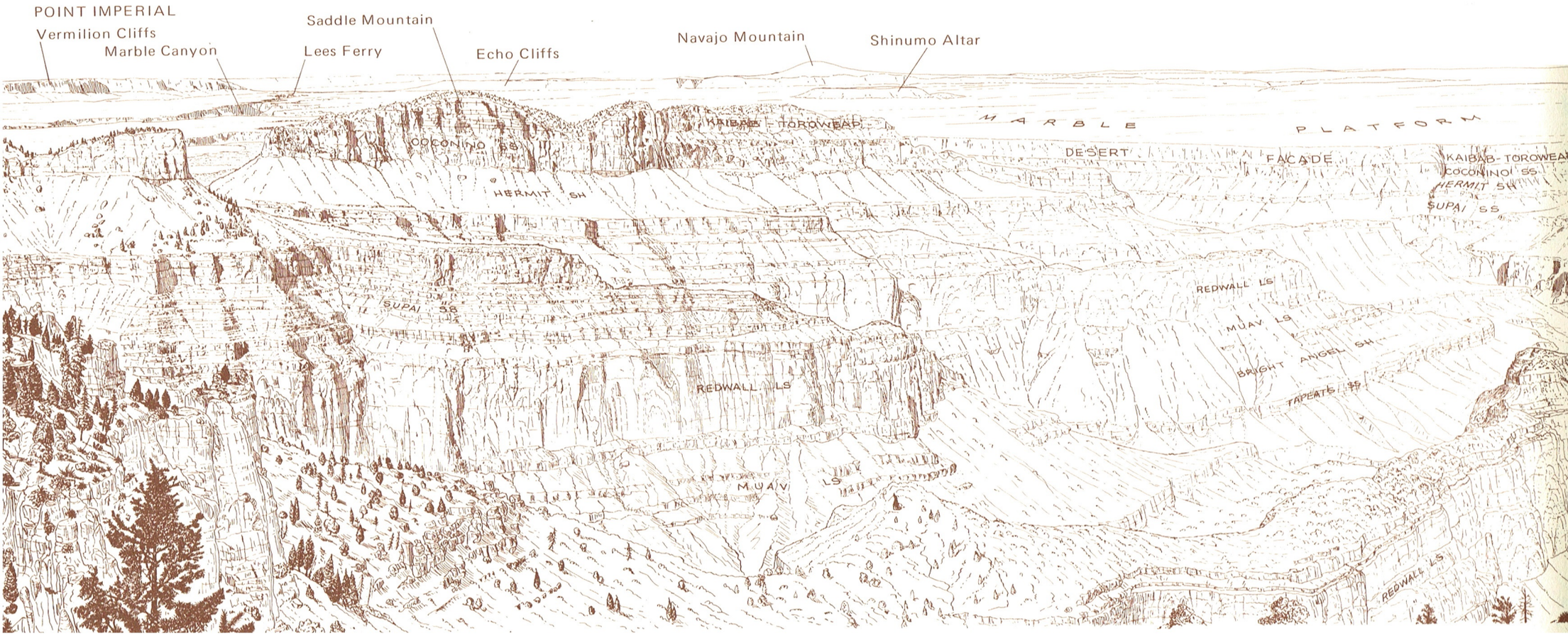
The short walk to the point demonstrates the pronounced effect which the different environment created by the exposure of these spurs and projections has on the natural communities. In less than ¼ mile, a transition occurs from the Ponderosa Pine and White Fir forest to vegetation more typical of regions further down in the Canyon. This is due to a combination of circumstances, particularly the southern exposure of the north wall, and updrafts of warmer air from the inner Canyon.

The sequence and distribution of vegetation communities here is markedly different than any place on the South Rim, and deserves emphasis. Studying the east wall of Bright Angel Canyon, we see that the dense forests covering the Kaibab Plateau proper extend down through the rather fragmented Kaibab Limestone to the top of the Coconino, and even farther down in places. Mountain brush communities and pinyon-juniper stands extend through the Supai to the top of the Redwall, and on north and east faces, into the Bright Angel Formation. This is in marked contrast to the situation on the South Rim, where the steeper profile of the cliffs and the generally drier conditions preclude the growth of trees any great distance below the rim.

Roaring Springs Canyon is incised well back into the plateau just east of the Point. The "roar" of the springs is quite audible, although they are located nearly 3500 feet below the trail. These springs are the source of most of the culinary water supplies on both rims. The water has been pumped up to the North Rim for many years, but only recently has a pipe line been constructed across the Canyon which will eventually carry water to Grand Canyon Village on the South Rim.

The North Kaibab Trail, a section of the transcanyon trail system, begins at the head of Roaring Springs Canyon, which it descends into Bright Angel Canyon proper and finally reaches the Colorado River near Phantom Ranch, a trail distance of some 14 miles. One may then ascend to the South Rim by one of two main routes (see page 26).

Mule Deer, *Odocoileus hemionus*. Common on both rims.



POINT IMPERIAL

Location: Eight miles east of the junction of the North Entrance Road with the Cape Royal Road; it is the most easterly of the rim points accessible to visitors.

Elevation: 8803'

Point Imperial provides an unusually broad panorama of the Canyon scenery, and many unique features can be seen from this area which are obscure or poorly exposed elsewhere. The vast expanse of the Marble Platform and the Painted Desert beyond is best seen from this viewpoint, and the effects of the great flexure of the East Kaibab monocline are evident.

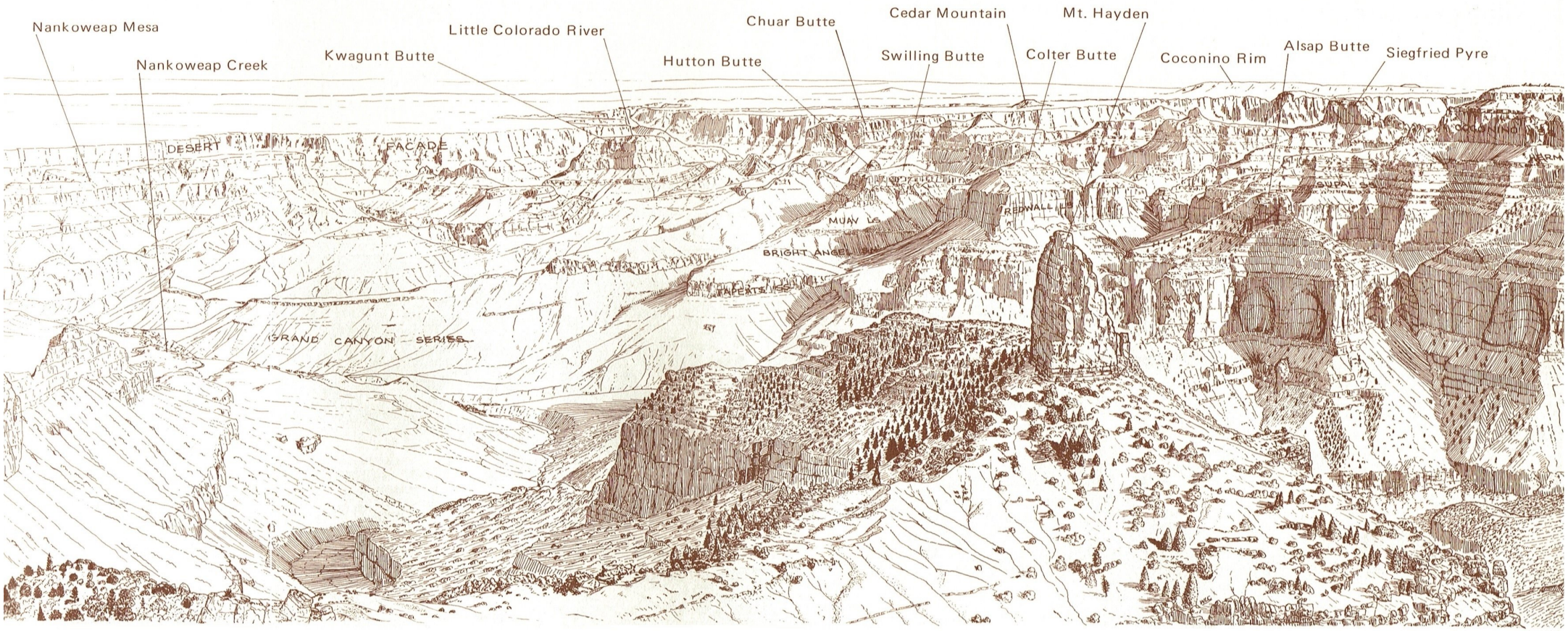
The Canyon at Point Imperial is slightly more than 9 miles wide, but it is highly asymmetrical. The river, which cannot be seen here, flows close to the east wall of the Canyon, and it is less than a mile from the east rim. The north or west rim at Point Imperial is 8803 feet high, whereas the east rim is only 6080 feet.

Marble Platform

One of the more impressive and significant features seen from Point Imperial is the vast expanse of the broad Marble Platform, a nearly flat, featureless surface formed atop the resistant Kaibab Limestone. This surface slopes gently to the east and is nearly 3000 feet lower than Point Imperial. On a clear day many of the prominent topographic features of northcentral Arizona can be seen to the east near the skyline; these same features are seen at close hand by travelers on U.S. Highway 89 from Flagstaff to Page, and 89A to Lees Ferry. To the left (west) on the skyline are the Vermilion Cliffs, which trend east and west near the Utah-Arizona line. These rocks are flexed into a large monocline near Lees Ferry, and the cliffs turn abruptly south and are then known as the Echo Cliffs. To the north can be seen a deep gorge cut through the Marble Platform by the Colorado River. This is known as Marble Canyon; it extends from Lees Ferry to the beginning of the Grand Canyon proper, near the mouth of Nankoweap Creek due east of Point Imperial, although Powell defined the Grand Canyon as beginning at the mouth of the Little Colorado River. On a clear day Navajo Mountain, a large dome located some 80 miles away in southern Utah, can be seen from Point Imperial. The butte known as Shinumo Alter rests upon the Marble Platform in the middle distance. This is an erosional remnant of soft red Moenkopi Shale which has not yet been stripped away from the surface of the Kaibab Limestone.

The Canyon Walls

The east wall of the Canyon is very steep and the rim is only slightly more than 3000 feet above the river. The upper rock units are not eroded into well-defined alternating cliffs and slopes, but form a steep, nearly vertical wall known as the Desert Facade. Below the east rim the Colorado River



flows through an inner gorge cut in the Redwall Limestone, and therefore cannot be seen.

The foreground in the Point Imperial area is carved on the upper Paleozoic formations, and the typical erosional characteristics of each formation are apparent. The Kaibab and Toroweap formations form the upper gray cliff. The Coconino Sandstone forms the prominent white cliff below. Mt. Hayden, a large prominent white pinnacle resting on the underlying red Hermit Shale in the foreground to the south, is a remnant of the Coconino Sandstone.

In contrast to the scenery at most viewpoints the section of the Canyon seen from Point Imperial is relatively complex, and much of the inner part of the Canyon is carved on the tilted red and gray strata of the Grand Canyon Series. There is no Granite Gorge and no well-defined Tonto Platform, features which dominate the lower part of the Canyon as seen from most other viewpoints.

The deformation of the rocks in the vicinity of Point Imperial is well expressed by the twisted and upturned edges of the strata in the vicinity of Kwagunt Butte.

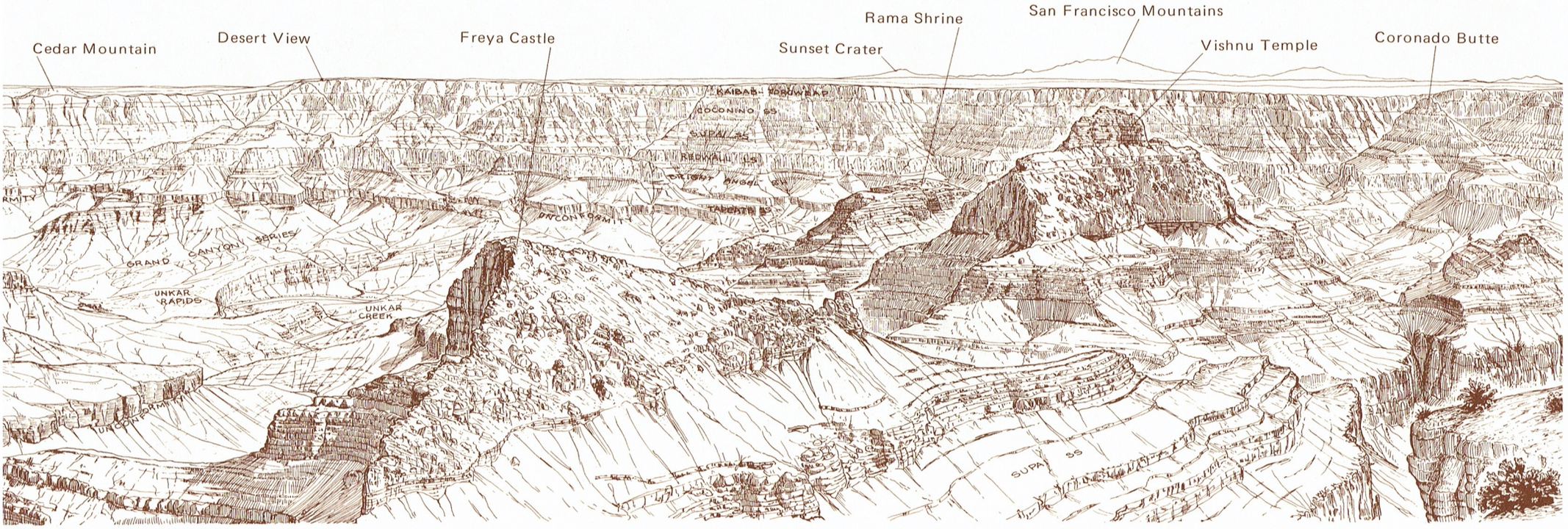
Ecology

Point Imperial is the highest of all the developed rim points; for this reason, the visitor finds himself viewing the panorama from beneath and between the large evergreens, a unique experience in the Canyon. The forest consists of Ponderosa Pine, White Fir, and Douglas-fir. This forest is confined only to moister areas with deeper soils. These large conifers occur as much as 1000 feet below the rim, but only on north-facing or otherwise shaded portions of the Canyon walls and slopes. Some of these larger trees even occur well below the Redwall, as seen on the lower slopes of Alsap Butte and Brady Peak. Generally, however, the Ponderosa Pine-Fir forest is gradually replaced by the pinyon-juniper community more characteristic of drier soils. This "pygmy" forest of pinyon-juniper extends well down onto the lowest slopes of the valley of Nankoweap Creek. In contrast to the forested terrain in the immediate foreground, the vast expense of the Painted Desert and Marble Platform along the eastern horizon is essentially devoid of prominent vegetation. In fact, the only plants of consequence growing there are the desert shrubs.

Birds and mammals provide most of the obvious animal activity at Point Imperial. Reptiles are almost entirely absent here, owing to the fact that the cooler temperatures and shorter season of biotic activity associated with the higher elevation pose temperature regulation problems for so-called "cold blooded" animals.

The birds are mainly those forms typical of the conifer forests, such as the Pinyon and Steller's Jays, Clark's Nutcracker, Western Tanager, Ruby-crowned Kinglet, and various woodpeckers. The visitor might expect to see wild turkeys and Blue Grouse on the drive out to Point Imperial.

Chipmunks are the mammals most likely to be encountered at the Point; at least three different species are present. Other mammals to be expected are the Golden-mantled Ground Squirrel, Kaibab Squirrel, Spruce Squirrel, and Porcupine. Mule Deer may be seen most anytime, but especially towards evening in the open meadows along the roads. Other mammals, including the predatory species, are nocturnal and therefore infrequently seen by most visitors.



CAPE ROYAL

Location: Cape Royal is located on the southern end of the Walhalla Plateau, a large promontory of the North Rim which extends southward to within five miles of the Colorado River. It is 23 miles by road from Grand Canyon Lodge with a number of scenic viewpoints along the way. Cape Royal provides views to the east, south, and west which collectively reveal a large segment of the eastern part of the Canyon.

Elevation: 7865'

Cape Royal East

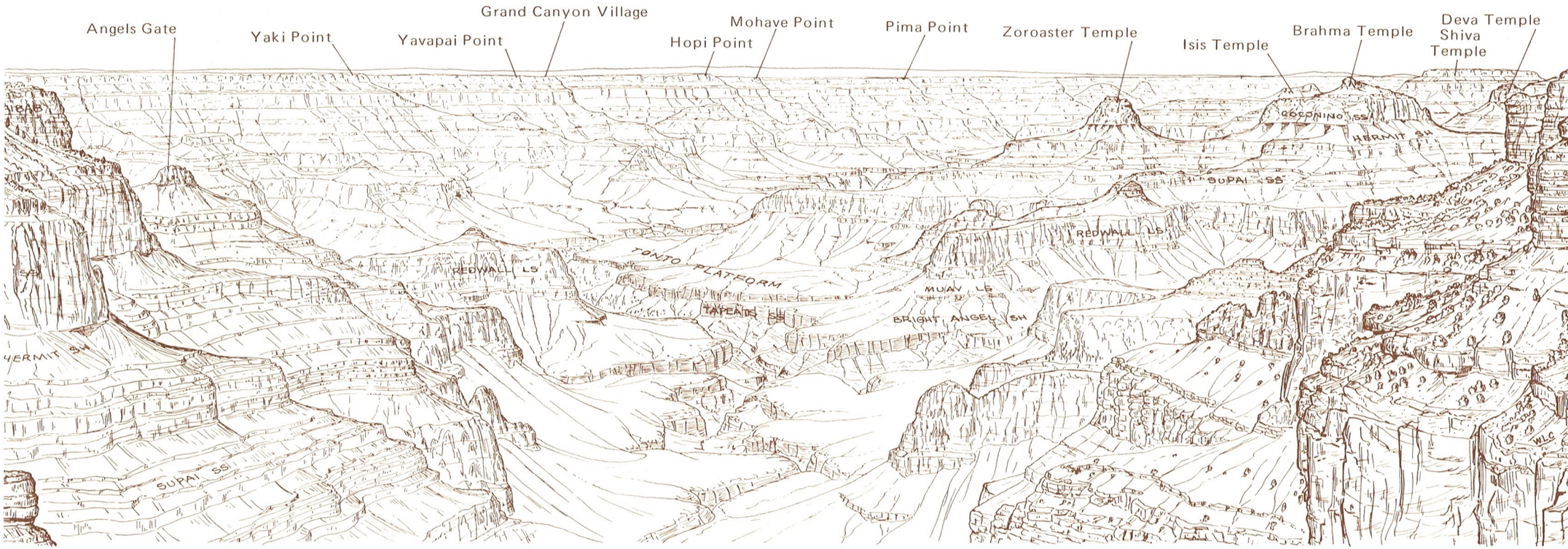
The Canyon landscape seen to the east from Cape Royal is dominated by the east wall, which appears steep and relatively undissected compared to the North Rim, which is highly serrated by large reentrants and amphitheaters. The Palisades of the Desert is the steepest part of the east wall; it is the single vertical cliff formed by the Kaibab, Toroweap, and Coconino formations. Cedar Mountain, a remnant of the Moenkopi Shale which rests upon the Kaibab Limestone, is seen in the background beyond the rim. To the south, the higher peaks of the San Francisco volcanic field rise nearly 6000 feet above the plateau surface.

Within the Canyon the angular unconformity separates the horizontal Paleozoic rocks from the underlying tilted Grand Canyon Series. The red shales and siltstones of the Grand Canyon Series are non-resistant and respond to erosion to form a broad valley of rolling hills at the bottom of the Canyon. This stands out in marked contrast to the V-shaped Granite Gorge which dominates the lower part of the Canyon to the east. The small segment of the river visible from the viewpoint is a meander bend at the mouth of Unkar Creek. Unkar Rapids can be seen near the upper end of the meander.

Erosional remnants in the foreground are Freya Castle and Vishnu Temple, isolated mesas held up by the resistant Coconino Sandstone and small vestiges of the overlying Kaibab-Toroweap formations.

Cape Royal West

The view to the west from Cape Royal is of the most familiar part of the Canyon. Many viewpoints on the South Rim can be seen as well as many of the temples on the North Rim. The Tonto Platform is well exposed in the foreground in the lower part of the Canyon. An excellent view is also provided of the Redwall Limestone, the bold



cliff midway down from the rim. The white wall formed by the Coconino Sandstone is also most impressive. Zoroaster Temple and Brahma Temple exist as isolated buttes capped by the white Coconino Sandstone or the gray Kaibab-Toroweap formations. The asymmetry of the Canyon is obvious from this viewpoint, as the south wall is relatively straight and rises rapidly from the Tonto Platform, but the north wall is dissected into isolated buttes and mesas.

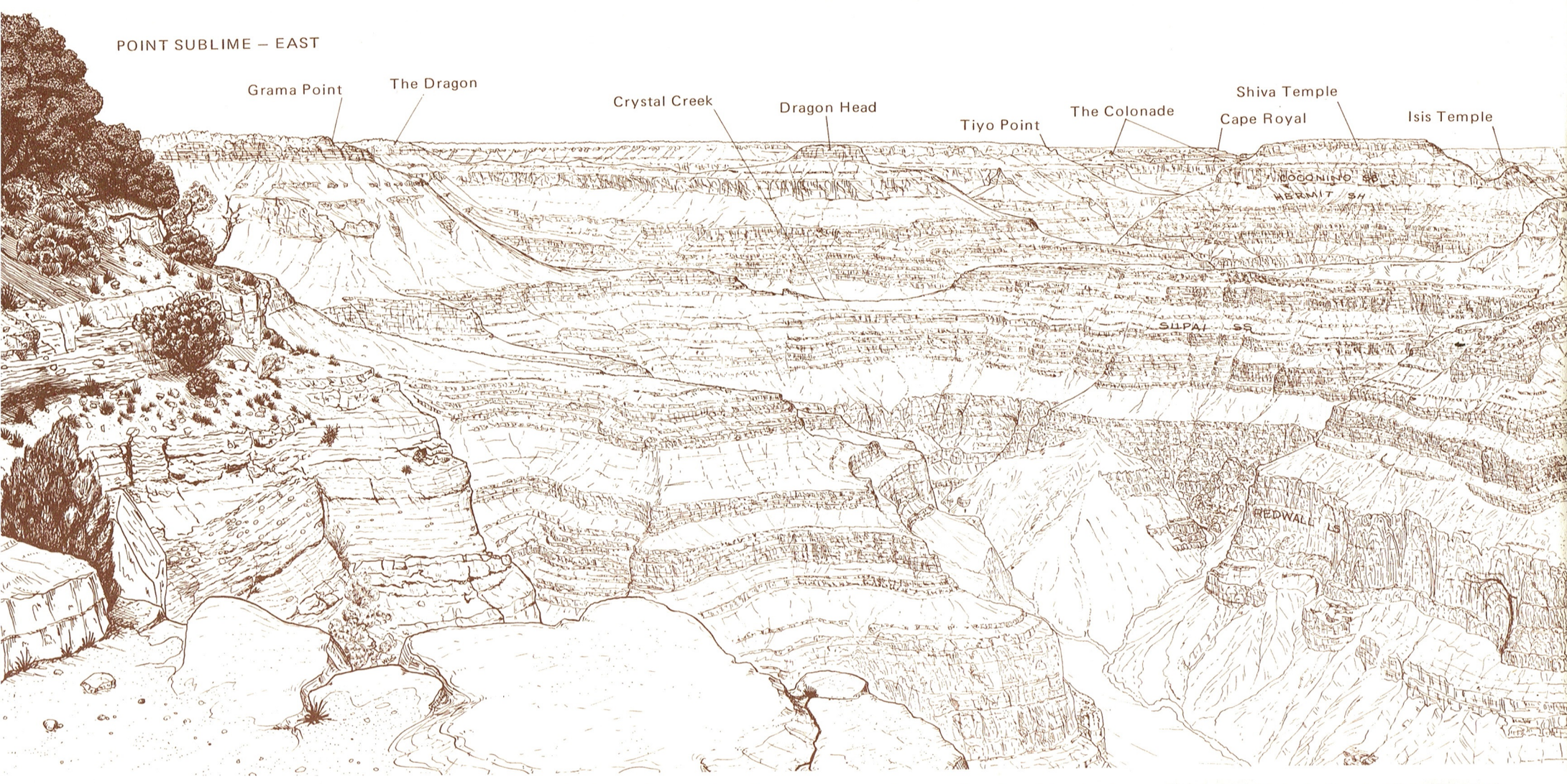
Ecology

The drive to Cape Royal, one of the most scenically rewarding automobile trips within the Park, also provides many features of biological interest. The last 15 miles of the road extend through the forests of the Walhalla Plateau. While there are some stands of aspen and spruce, the forest consists primarily of mature Ponderosa Pines. Since this is the habitat of the Kaibab Squirrel, it is often possible to see these unique animals on the drive to or from Cape Royal (see discussion, p. 14).

Extending from the Cape Royal parking area is an excellent self-guiding trail of one-half mile, leading to rim points affording views of this particularly wide part of the Grand Canyon. The Ponderosa Pine forest, characteristic of most of the Walhalla Plateau, has been replaced by vegetation indicative of drier conditions, even though the elevation is over 7800 feet. This is probably the effect of warmer air from the inner canyon rising up to the higher rim faces. The pinyon-juniper forest is well developed, with an understory consisting of cliffrose, serviceberry, buffaloberry, mountain mahogany, and blackbrush; sagebrush is also present, but not as conspicuous as some of the other shrubs. Representing the "desert" elements in the flora are pricklypear cactus, yuccas, and Mormon tea.

Many places within the Canyon have yielded evidence of early human habitation. One such site is located on the terraces just west (right) of Unkar Rapid, where archaeological excavations have demonstrated the presence of at least two separate occupations. The first occurred about 900 A.D., but was rather temporary. The second settlement, beginning about 1080 A.D., was much more permanent, and led to the construction of several multi-room dwellings. Agricultural terraces were also developed here; perhaps the crops were irrigated with Colorado River water. Occupation at this site evidently terminated about 1150 A.D.

Walhalla Plateau was also the site of an occupation by Pueblo cultures, and other such sites are known from the North Rim. The best preserved examples of Pueblo architecture in the Park are at Tusayan Ruin on the South Rim, near Lipan Point. The National Park Service operates a museum and interpretive services at Tusayan during the summer months.



POINT SUBLIME

Location: Seventeen miles southwest from the North Entrance Station. The road to Point Sublime is maintained for summer visitors but is unpaved. Point Sublime is located at the terminus of one of the longest promontories projecting from the Kaibab Plateau; hence the viewer has the sensation of being projected well out into the Canyon proper, with a panorama of more than 270° spread before him.

Elevation: 7458'

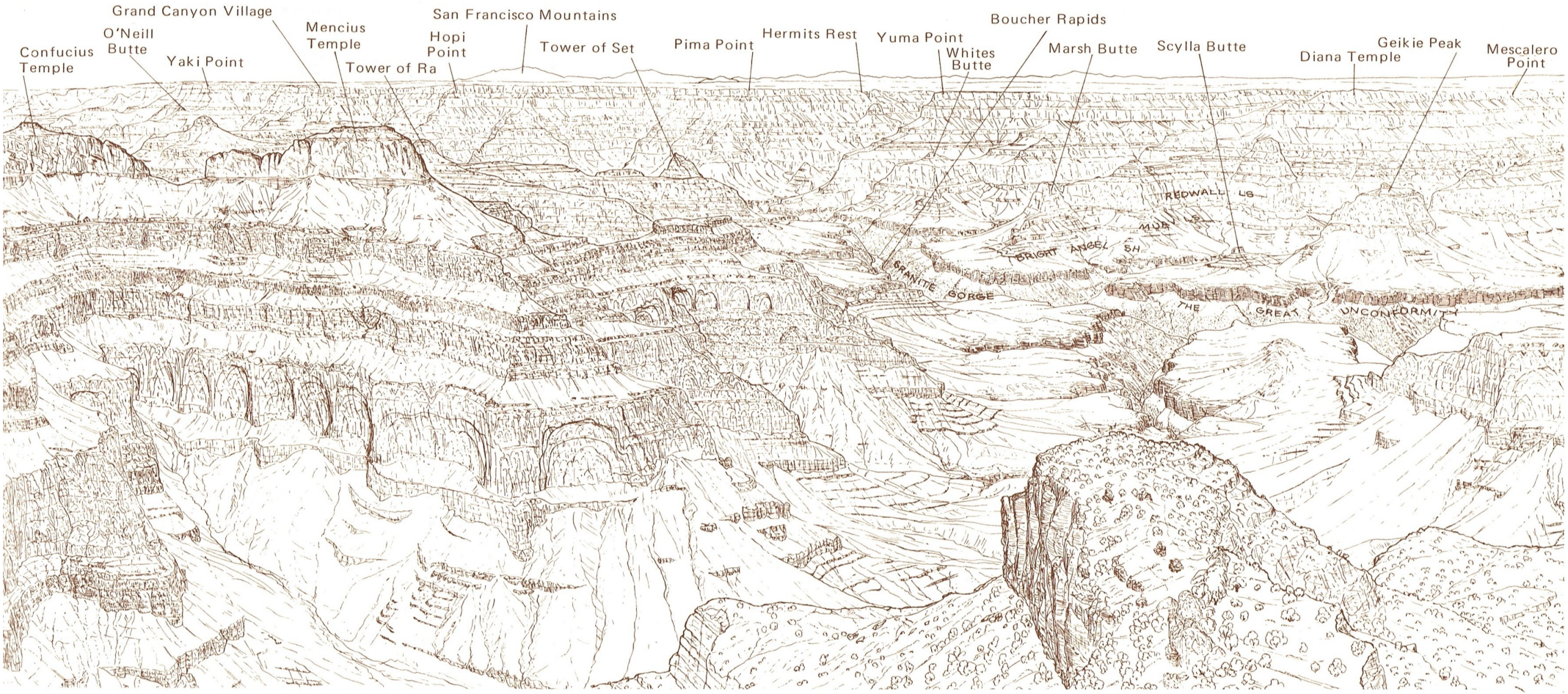
Geologically, the scene from Point Sublime may at first appear to be a disorganized maze of buttes, mesas, and walls of alternating cliffs and slopes, but reference to the map will reveal that land forms here are rather symmetrical. Tuna Creek flows due south and separates two long scalloped spurs which project far to the south, to within a half mile of the river. The foreground on both sides of Point Sublime is, therefore, dominated by the red erosional forms of these two ridges with a view of the Granite Gorge between.

Point Sublime (East)

The view eastward from Point Sublime is dominated by erosional forms carved in the great reentrant on the west flank of the Kaibab Plateau, so that most of the features seen to the east are north of the river. This area is eroded by the tributaries of Tuna Creek and Crystal Creek which flow south and southwest into the Colorado. Most of the scenery in the eastern foreground is formed on a long southward trending spur carved on the red Supai Sandstone and underlying Redwall Limestone. This ridge is capped by small erosional remnants of the white Coconino Sandstone topping the features known as Confucius Temple and Mencius Temple. In many respects it is similar to Sagittarius Ridge west of Point Sublime, in that both represent incipient segments of the Esplanade. Most of the topography is developed on alternating low cliffs of sandstone and gentle slopes of shale in which the horizontal layering is strongly expressed. The similarity extends to the underlying bold cliff of the Redwall Limestone.

In the background Shiva Temple, a large mesa capped by the Kaibab Limestone, is separated from the North Rim of the Canyon by erosion controlled by a fault zone. The Dragon Head, located north of Shiva Temple, is a similar but smaller butte capped by the Kaibab Limestone.

Point Sublime is closer to the river than any accessible point on the North Rim, and for this reason affords an excellent view of the inner gorge, the river, and the bottom of the Canyon. The Tonto Platform is in view beyond the narrow ridge of Coconino Sandstone immediately below the point. Boucher Rapids is in the small stretch of river



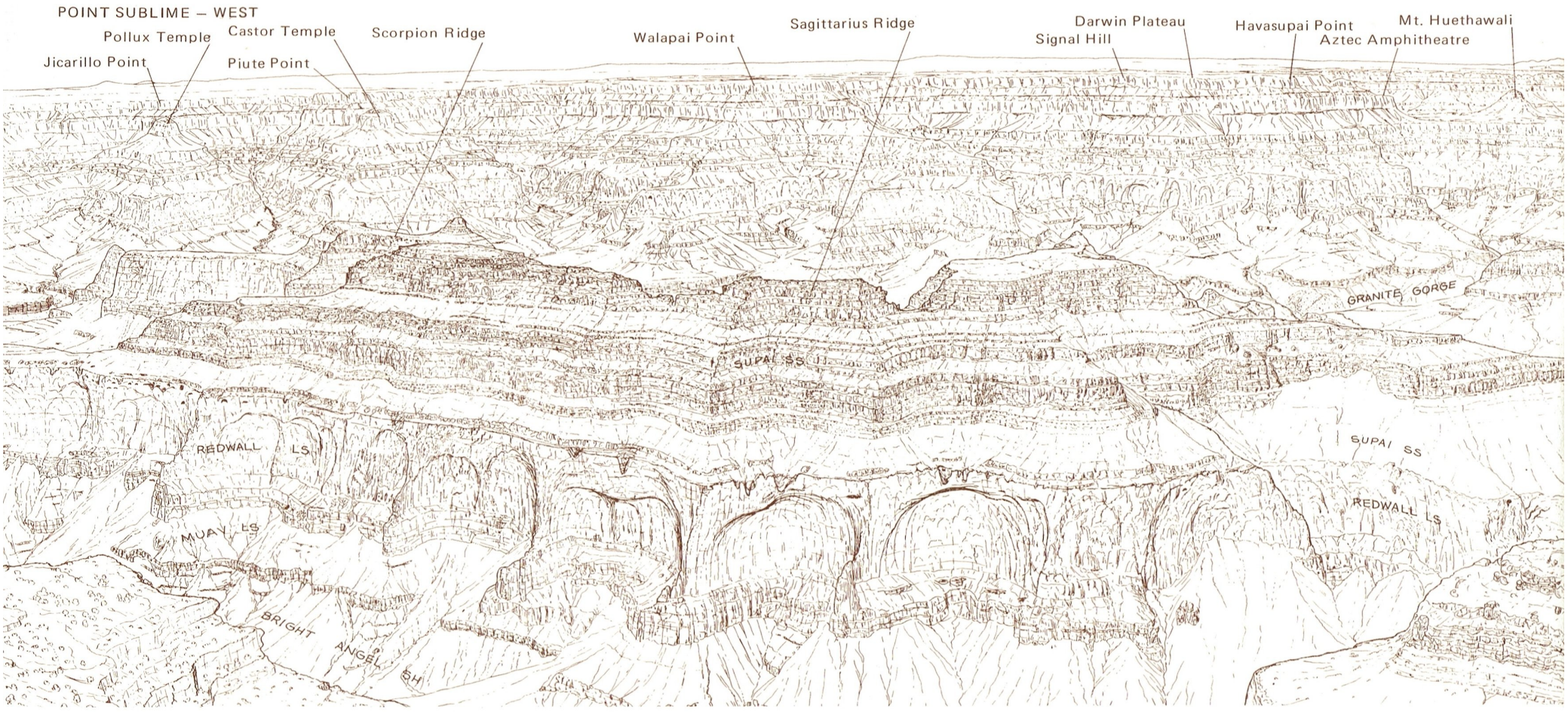
exposed in the Granite Gorge. The large volcanic field of the San Francisco Mountains can be seen on the skyline in the background to the south and southeast. The highest elevation, Humphreys Peak, is roughly 6000 feet above the Coconino Plateau, whereas the bottom of the canyon is some 5000 feet below plateau level.

The South Rim of the Canyon, visible from this viewpoint, is 7 to 9 miles away. The south wall is not nearly as dissected by erosion as the north wall, and much closer to the river. The broad expanse of the Coconino Plateau is inclined to the southwest and appears to be practically featureless.

Ecology

In the tributaries at the head of Tuna Creek, directly beneath the Point, can be seen stunted cottonwoods, mesquite, and other forms typical of streamside communities. With the aid of a binocular, it is possible to detect animal trails in the lower slopes and along the streambeds. These are probably "maintained" by wild burros and bighorn sheep. Mule deer may venture this far into the inner canyon, but are more numerous on the plateaus. Evidence of their activity is to be seen closer at hand; most of the cliffrose plants atop the Point have been overgrazed by deer to some degree. This is a favorite browse species for the mule deer, and is extensively utilized during winter.

The view of Shiva Temple from Point Sublime is the closest to be obtained from any of the points readily accessible by automobile. With an area of about 275 acres, Shiva is the largest of the isolated buttes detached from the North Rim. The low vegetation atop Shiva, appearing as shrubs or brush at this distance, is actually a stand of young Ponderosa Pine. The top of Shiva was first explored in modern times by an expedition from the American Museum of Natural History in September, 1937. The principal purpose of the trip was to collect mammal specimens and compare them with representatives from the adjacent North Rim, with a view to determining whether any new races or varieties had developed in the time that had elapsed since isolation of Shiva from the rim. No such evidences of speciation were detected, probably because physical isolation is not yet complete, and the larger mammals are evidently still capable of moving back and forth from the rim; even evidence of mule deer was found atop the Temple. There is still the possibility, however, that minor changes in the gene pool have occurred, at least in the less motile small mammal populations. Incidently, the 1937 expedition discovered evidence to prove that they were not the first humans to have visited Shiva's summit. Remnants of campsites, flint workings, and potsherds indicated that Indians had also frequented the top.



Point Sublime (West)

The westward view from Point Sublime reveals the beginning of a major change in the Canyon profile. The great terrace of the Esplanade, a feature which becomes as much as 5 miles wide farther to the west, is well expressed as the broad terrace atop the Supai Formation in the vicinity of Wheeler Point, Apache Point, and the Aztec Amphitheater. From this point of view, the Esplanade appears to be best developed on the south side of the Canyon below Havasupai Point, where the terrace is about 2 miles wide. Mt. Huethawali, a prominent butte or erosional remnant capped by the Coconino Sandsone, rests on the surface of the Esplanade in this vicinity.

In the foreground the upper surfaces of the large spurs called Sagittarious Ridge and Scorpion Ridge are in essence parts of the Esplanade, although the flat upper surface of the Supai Formation is breached in many places. This particular type of land form is unique to the western part of the Canyon and is not found east of the Point Sublime vicinity.

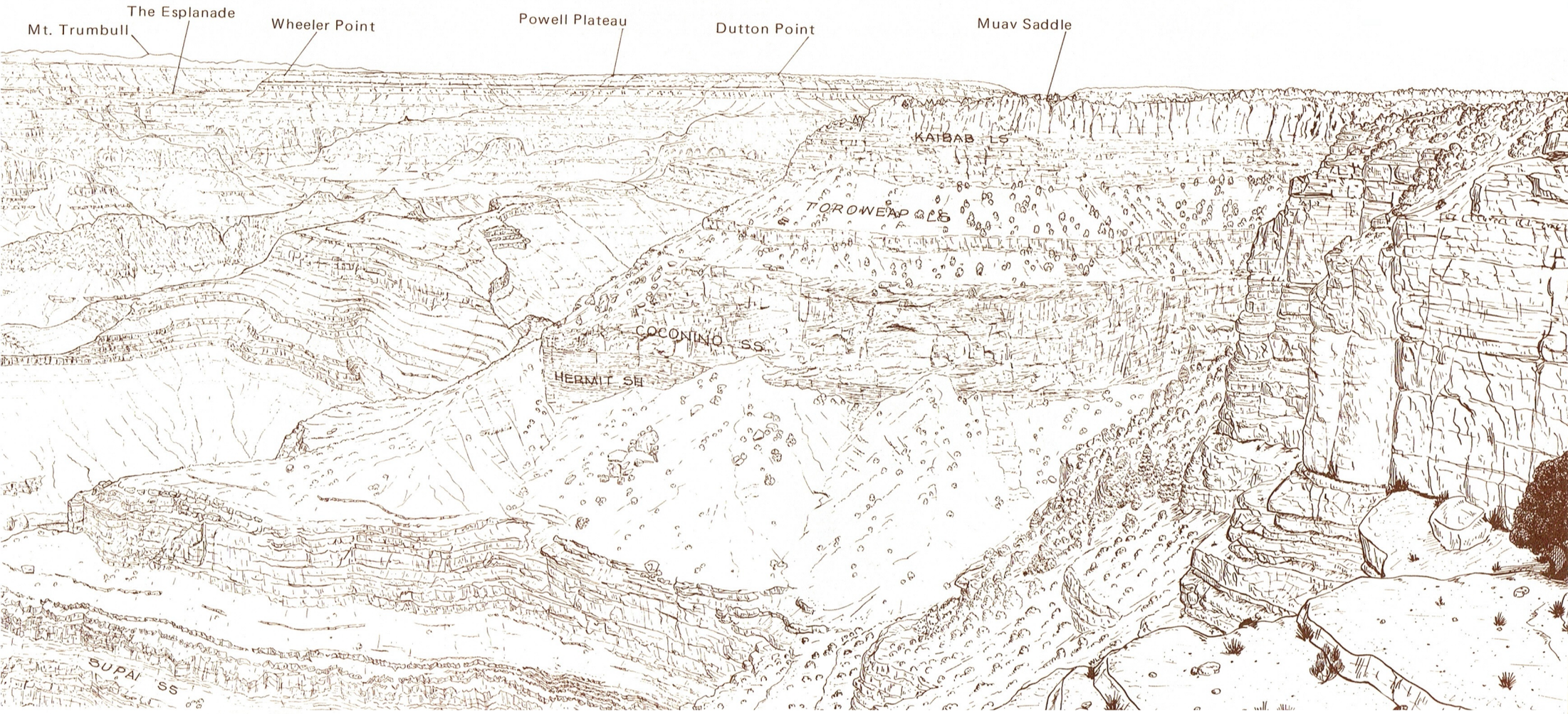
The Redwall Limestone forms the vertical cliff in the middle of Sagittarius Ridge; it is characteristically scalloped by numerous large alcoves, some of which have developed sizable reentrants. This feature, so typical of the Redwall's response to erosion, is exceptionally well developed here, and several of the alcoves have been accentuated to the extent that large overhanging cliffs have developed.

In contrast to the wide terrace developed on the top of the Supai, the Tonto Platform, which is much wider to the east, is very narrow in this part of the Canyon, less than ¼ mile wide in some places.

The Muav fault trends in a northwest direction in the valley between Point Sublime and Sagittarius Ridge. Flexing of the strata in the Supai Formation on the downthrown side is visible near the North Rim in the west foreground.

The volcanic field of the Uinkaret Plateau is visible on the far western horizon. Numerous volcanic cones are vaguely expressed by the highly irregular skyline. It is within this area (in Grand Canyon National Monument) that recent lava flows have partly filled some of the major tributary valleys and greatly modified the character of the Canyon.

A dominating feature to the west is the Powell Plateau. In many respects it resembles the Walhalla Plateau to the east, but the top of Powell Plateau has been completely detached from the North Rim by headward erosion in Muav Canyon and Saddle Canyon. A glance at the map (page 48) will reveal that with continued erosion along Bright Angel Canyon and Nankoweap Canyon, the upper surface of Walhalla plateau will also eventually be disconnected from the North Rim. Powell and Walhalla plateaus are also similar in that the erosion along the canyons, which either partly or completely separate them from the North Rim, is controlled by faults.



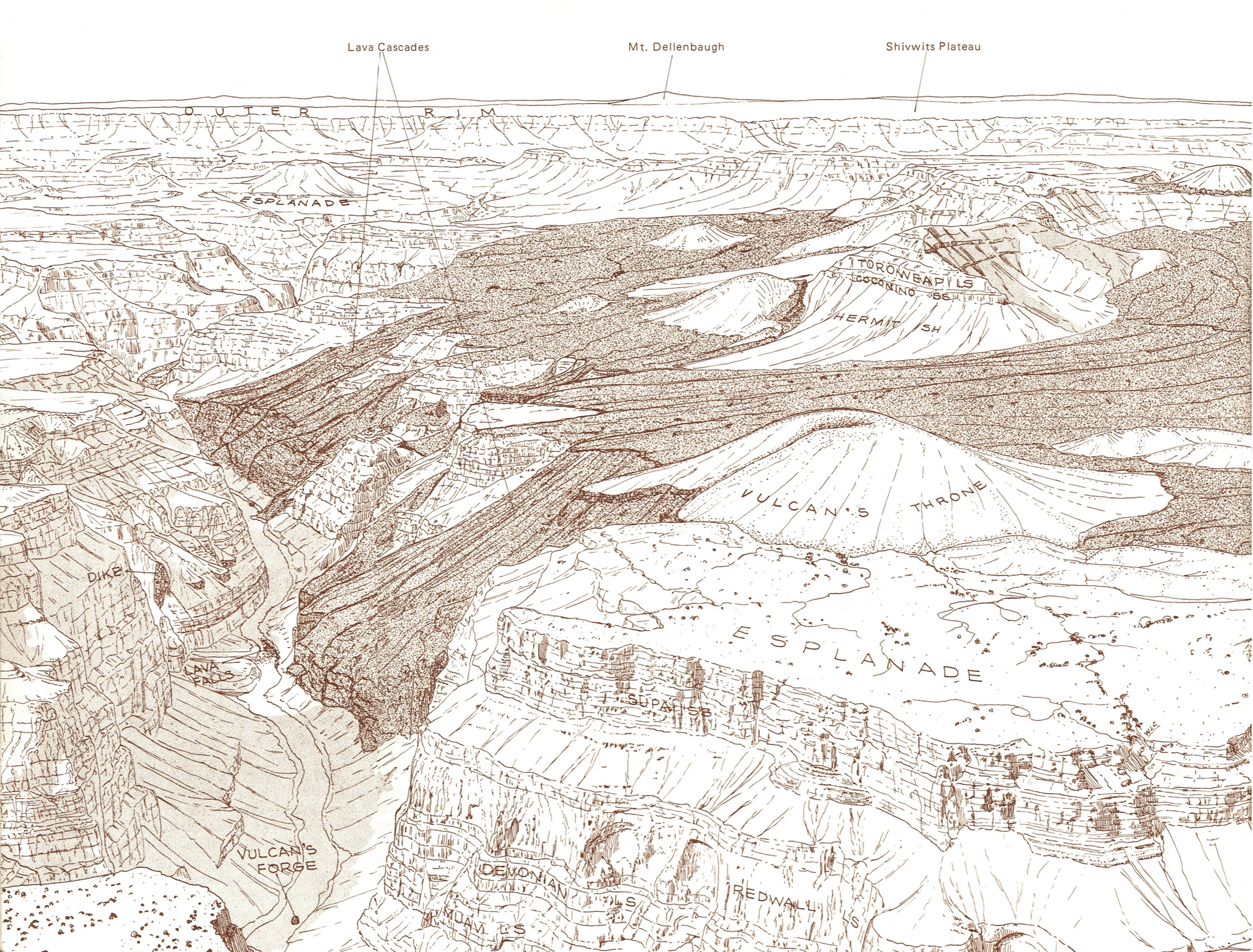
Ecology

Owing to the nature of this projecting salient a number of climatic modifications occur, which are reflected in the plant and animal communities present. The approach to the Point serves, therefore, as an excellent example of change occurring along an ecological gradient. From the fairly dense pine and aspen forests of the Kaibab Plateau, a seemingly abrupt transition occurs to more arid communities. There is first a mountain brush community dominated by scrub oak and related shrubs, then a pinyon-juniper woodland with some elements of the low desert flora. A glance at any of the adjacent points will show that this same effect is discernable, as the eye quickly passes from the tall Ponderosas back from the rim through intermediate shrub stages to the semi-desert communities at the end of the point.

In the vicinity of the parking area, the open stand of Pinyon Pine and Utah Juniper is supplemented by such shrubs as cliffrose *(Cowania* sp.), big sagebrush *(Artemesia tridentata),* Mormon tea *(Ephedra* sp.), blackbrush *(Coleogyne* sp.), and several species of native grasses. Most striking is the so-called "century plant", *Agave utahensis,* with tall yucca-like stalks. Seasonal blooming of flowering plants continues well into the fall, aided no doubt by the milder conditions prevailing at the Point.

It has been theorized that the reason the points favor development of the more arid communities is that strong updrafts from below carry warmer air out of the Canyon and onto projecting portions of the rim. Such thermal currents are responsible, then, for localized modification of the prevailing climate. This in turn permits plants and animals normally associated with the more arid conditions of the inner canyon to exist at much higher elevations. The effect can be seen at nearly all points on both rims, but is perhaps best expressed here at Point Sublime. For this reason it is an excellent place to observe the activity of hawks and other soaring birds which utilize these currents.

Down over the lip of the point, the pinyon-juniper community is seen to extend into the Supai formation, with a transition then occurring to the desert shrub communities typical of lower elevations within the Canyon. This can also be seen to excellent advantage on the point directly to the west. It should be re-emphasized that this transition in life forms is the result of a corresponding gradient in soil type, moisture, temperature, wind, light intensity, and other environmental factors.


Lava Cascades
Mt. Dellenbaugh
Shivwits Plateau
OUTER RIM
ESPLANADE
TOROWEAP LS
COCONINO SS
HERMIT SH
VULCAN'S THRONE
DIKE
LAVA FALLS
ESPLANADE
SUPAI SS
VULCAN'S FORGE
DEVONIAN LS
REDWALL LS
MUAV LS

GRAND CANYON NATIONAL MONUMENT

Location: Sixty-seven miles southwest of Fredonia, Arizona. Toroweap Point is reached by a gravel road from the town of Fredonia, Arizona; an alternate route leads south from St. George, Utah. The roads are well maintained in good weather, but there are no supplies, water, gas, lodging or meals available, and visitors should plan to be self-sufficient during their stay. A small campground is located back from the rim of the inner gorge.

Elevation: 4600'

The Canyon Profile

The western part of the Grand Canyon is strikingly different from the better known regions in the National Park to the east. It is nonetheless spectacular, however, and to many visitors is even more awe-inspiring. Here the Canyon profile consists of an outer rim, a broad platform called the Esplanade, and a vertical-walled inner gorge 3000 feet deep. The upper sequence of cliffs which form the outer rim are carved on the resistant Kaibab, Toroweap, and Coconino formations. These beds have retreated back from the river to form the Esplanade terrace, as the weak non-resistant Hermit Shale has been stripped away. As a result, the Esplanade has developed on the underlying Supai Sandstone and constitutes one of the most prominent features in this part of the Canyon. It is approximately five miles wide, and is eroded into a rough hummocky surface with numerous small shallow basins. The steep inner gorge has developed in the western Grand Canyon because of the superposition of a thick sequence of hard limestone and sandstone units with only minor amounts of shale. These include the Supai Sandstone, and the Redwall, Devonian, and Muav limestones. These form a series of vertical cliffs, some of which are more than 600 feet high, separated by narrow talus slopes. The walls of both the inner and outer canyons are steeper than any part of the Canyon to the east.

The Uinkaret Volcanics

The road to Toroweap Point traverses part of the Uinkaret volcanic field, a region of considerable volcanic activity which has formed hundreds of cinder cones and basaltic lava flows. Toroweap Valley is a major tributary to the Grand Canyon, extending 15 miles back from the river. It, together with Prospect Canyon to the south and Whitmore Wash 10 miles to the west, are unique in that they have been filled with lava and interbedded sediment to the level of the Esplanade. This permits one to drive down these valleys on a relatively flat surface into the Grand Canyon, across the Esplanade, and out to the rim of the Inner Gorge.

Spectacular lava cascades which spilled over the west rim of Toroweap Valley can be seen in the vicinity of the Ranger Station.

Vulcan's Throne

Vulcan's Throne is a large cinder cone perched on the rim of the Inner Gorge at the mouth of Toroweap Valley. The cone is located along the Toroweap fault, and rests on a sequence of lavas which fill this valley. It is approximately 3/4 mile in diameter and rises 567 feet above the surrounding surfaces. The drainage down Toroweap Valley has been blocked by Vulcan's Throne, so that a small shallow lake forms north of the cone during wet seasons.

Lava Cascades West of Vulcan's Throne

A short walk to the west of the campground provides one of the most impressive views of the entire Canyon. Here one can see that the lava which covers most of the Esplanade cascaded over the rim of the Inner Gorge into the Colorado River, 3000 feet below. Remnants of some of the intracanyon flows have been found downstream almost to Lake Mead, a distance of 86 miles.

Other evidence of recent volcanism in the Canyon include remnants of cinder cones adhering to the walls of the Inner Gorge, and numerous dikes which cut across the walls of the Canyon. Vulcan's Forge, a large volcanic neck, is located in the middle of the river directly below the Cascade viewpoint. It is approximately 70 feet in diameter and protrudes 50 feet above the river. Also in view are Lava Falls Rapids, one of the largest and most dangerous in the entire Canyon; from the rim, they appear deceptively innocuous, with no hint of the large boulders, wild maelstrom of water, and drop of some 30 feet which occurs here.

Lava Dams

In addition to the lava cascades, there are numerous remnants of older lava flows adhering to the walls of the Inner Gorge. They range in elevation up to more than 1400 feet above the river, but are best seen from the Canyon floor. An excellent example of a high level remnant can be seen on the south wall of the Inner Gorge, southwest of the campground. It is preserved in a small alcove just below the base of the Redwall cliff. Other remnants are visible at the mouth of Prospect Canyon, due south of Vulcan's Throne.

It is apparent from these deposits that lava flows formed great barriers or dams across the Colorado River and backed up the water to impound temporary lakes, some of which extended upstream into what is now the National Park area. As a lake would overflow, a new gorge was eroded through the lava dam, leaving only a few lava remnants clinging to the walls of the Inner Gorge in protected alcoves and reentrants. Later eruptions formed new lava dams, which were in turn subsequently breached by overflow of the river. This process was apparently repeated several times, as evidence of at least 6 different dams has been found within the Canyon.

Radioactive measurements indicate that some of the older lava dams are 1.2 million years in age. This date is significant, in that it indicates that the Grand Canyon was cut to essentially its present depth over a million years ago.

The Toroweap Fault

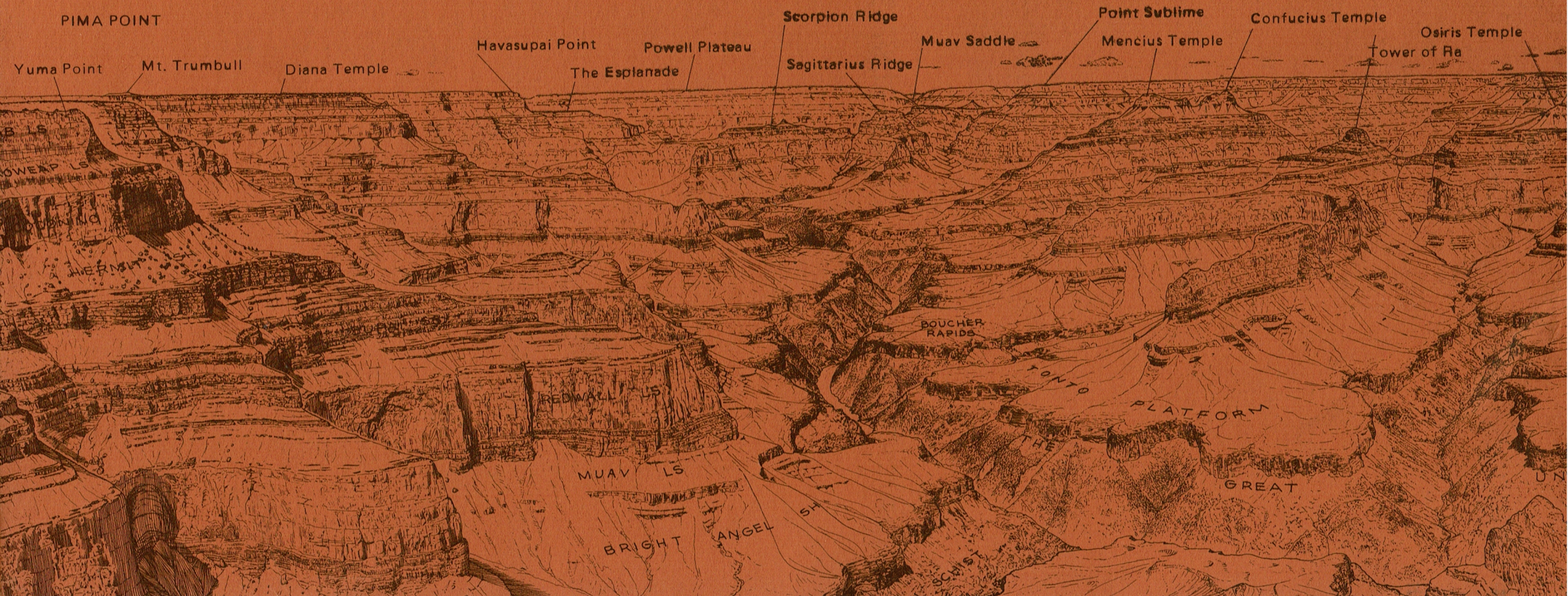
The Toroweap fault is one of the major zones of dislocation in the western Grand Canyon. It trends north-south, and has controlled the erosion and development along Toroweap and Prospect Canyons. Displacement along the fault is evidenced by the vertical offset in the surface of the Esplanade. If the visitor looks across to the south side of the Canyon and follows the surface of the Esplanade westward to the mouth of Prospect Valley, he will see that the upper part of the Supai Formation below the small cone on the rim of the Inner Gorge is 700 feet lower than the opposite side.

Ecology

At Toroweap Point proper, the visitor stands at an elevation (4600') considerably lower than that of any of the rim points in the National Park. As a consequence of the arid climate and the rather resistant sandstone substrate, the vegetation is sparse and desertlike, the only trees present being some rather stunted junipers and pinyons. Yuccas, *Agave,* cacti, and various desert shrubs are the prominent plants. The most noteworthy difference in animal life, as contrasted with the higher areas in the eastern Canyon, is probably the increased reptilian activity. Several species of lizards may be seen on a warm day; snakes, including rattlesnakes, are also present, but tend to be more nocturnal in their behavior.

Of the minor types of communities worthy of mention, one of the most interesting is the assemblage of organisms which develops in the temporary pools formed in the basins or "potholes" characteristic of the Supai Sandstone. A number of invertebrates may be found, but the most unique are undoubtedly the primitive crustaceans, such as tadpole shrimps and fairy shrimps. Even vertebrates are represented in the pothole ecosystem. Tadpoles of the red-spotted toad, *Bufo punctatus,* are found frequently in the spring. Obviously, the toads must complete their metamorphosis from aquatic to terrestrial stages before the potholes dry up. The eggs, resistant spores, or dormant larval stages of all of these animals are adapted to survive the periods of dryness; they emerge as active forms when water returns again.

modified from USGS topographic map of the Bright Angel Quadrangle


PIMA POINT
Yuma Point
Mt. Trumbull
Diana Temple
Havasupai Point
The Esplanade
Powell Plateau
Scorpion Ridge
Sagittarius Ridge
Muav Saddle
Point Sublime
Mencius Temple
Confucius Temple
Tower of Ra
Osiris Temple
BOUCHER RAPIDS
TONTO PLATFORM
THE GREAT
MUAV LS
BRIGHT ANGEL SH
SCHIST